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THE POPULAR Science Review

EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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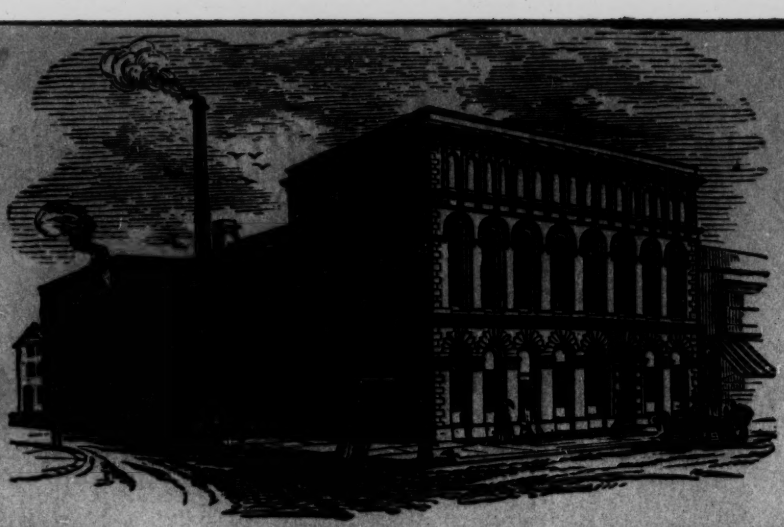

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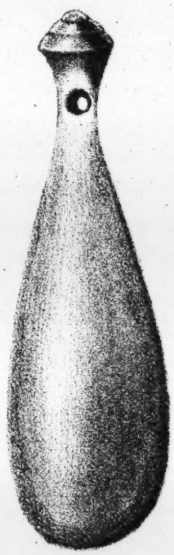

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WORKED JADE & JADEITE.

ON JADE AND KINDRED STONES.

By F. W. RUDLER, F.G.S.

[PLATE VIII.]

SCIENCE is unquestionably the arch-foe to superstition; yet superstition, it must be conceded, has unwittingly rendered an occasional service to the cause of science. How ill, for instance, might it have fared to-day with the student of prehistoric archæology if our ancestors had been free from any superstitious regard for those implements of stone—unknown alike in origin and use—which they occasionally brought to light with help of spade and plough! As long as the flint arrow-head was regarded as a "fairy dart," or the stone axe as a "thunderbolt," it stood in little danger of being heedlessly destroyed. Shielded by the supernatural origin to which it was referred, the relic may have been piously preserved, generation after generation, until in these latter days it has come to grace the cabinet of an archæologist. The time of real danger was not when there was too much superstition abroad, but when there was too little superstition, yet not sufficient science—when men had ceased to value a stone implement as talisman, or amulet, or charm, but were not sufficiently enlightened to recognise its true meaning and to value it on scientific grounds.

Much of the esteem which the ancients set upon precious stones was due, in like manner, to the superstitions by which such minerals were liberally surrounded. No doubt the properties which we prize at the present day—such as colour, brilliancy, and hardness—were equally prized in the remotest times at which precious stones were used; but above and beyond these obvious characters, overarching all these physical properties, there was the higher value derived from their metaphysical virtues. Some of these virtues were of a purely spiritual character, such as the power attributed to so many gems of dispelling vicious propensities and of inspiring purity of life in the owner. Others, however, were of less subtle nature, and were in fact medicinal rather than metaphysical.

In order to cure disease, it was in most cases considered sufficient to simply wear the stone, when its sympathy with the affected part brought its curative power into play. But in other cases recourse was had to the grosser method of internally administering the powdered gem. These superstitions naturally led men to seek eagerly for stones so marvellously endowed, and thus our knowledge of such minerals and of their mode of occurrence became widened. Stones which were reputed to possess therapeutic virtue were carefully preserved and studied in their minutest details. Who indeed would not diligently seek and fondly cherish an object which was at once a personal ornament and a specific against disease?

It is curious to note how wide-spread are the superstitions which have clustered around stones of a green colour. Belief in their efficacy has been held by the peoples of the New World not less than by those of the Old; they are mentioned in the most ancient works on such subjects; their virtues are extolled by mediæval writers; and, indeed, it may be doubted whether the superstitions have yet died out. To take the emerald alone, a catalogue of its reputed virtues would run to inconvenient length. Soon after the discovery of America, the Spaniards brought to Europe some curious green stones which were held to be singularly efficacious in their medicinal properties. From the fact that the mineral was a specific for diseases of the kidneys, it was termed by the Spaniards *Piedra di hijada*, or "stone of the loins." By those who were ignorant of Spanish, the term was naturally corrupted; and it needs no philological aid to see how *hijada* or *ijada* might gradually become transformed into *jade*. The stone was also known as *Piedra de riñones*, or "stone of the kidneys," whence arose the term *Lapis nephriticus*, or *Pierre néphritique*, and finally the mineralogical designation *nephrite*, from *νεφρὸς*, *kidney*.

It appears that the earliest recorded reference to this green stone as *Piedra de hijada*, occurs in the work of a Spanish doctor, Nicolas Monardes, published in 1565.* In this work he gives an account of the medicinal products of the West Indies. The *materia medica* of a mediæval doctor included some extraordinary drugs, and the Spanish physician gives us a chapter *De la Piedra de Sangre y de la Piedra de la Yjada*, in other words, of the "bloodstone" and of the jade. Of the latter he says that the deepest green kind is the most prized, and that it is worked into various forms by the Indians, who wear the objects as amulets against diseases of the loins and of the stomach. So strong is the antagonism between the stone and the disease,

* "Historia Medicinal de las cosas, que se traen de las Indias occidentales, que siruen en Medicina."

that, by merely wearing a bracelet of jade, the fortunate possessor is kept free from any attack of such malady.

Among the many novelties which Sir Walter Raleigh introduced into this country, mention should be made of the jade-stone. Such at least is the testimony of Sir Hans Sloane, who refers to him when speaking of the hard green stone found as pebbles upon the shores of Jamaica. "This," says the naturalist, "is the *piedra hijada* of the Spaniards, and *Pierre de Jade* of the French authors, who magnify the virtues of it so as to make them incredible; nay, Mr. Labart, a French late author, would make us believe it cures epileptic fits. Sir Walter Raleigh first brought some of them to England, giving vast encomiums of them." *

Sir Hans Sloane describes this jade under the name of *Spleen-stone* or *Jasper viridis*. So close, indeed, is its resemblance to some kinds of green jasper that it was generally described by early authors under that name. For this reason, among others, there is considerable obscurity in the references of the older writers upon precious stones, and it is in many cases impossible to determine whether they mean jade, jasper, or some other dark green mineral. Those who care to thread their way through the maze of ancient and mediæval writers will find an able and sympathetic guide in Professor Fischer, of Freiburg-im-Baden, who, attacking the subject with Teutonic perseverance, has produced an exhaustive monograph on jade.†

From Nova Hispania the Spanish conquerors obtained some valuable green stones, among which jade was probably included. Curiously enough no jade is now known to occur in Mexico or in Central America, or indeed, anywhere on the American continent. Yet it seems beyond doubt that the mineral was employed in ancient Aztec art, and it appears to have been one of the stones to which the term *chalchihuitl* was applied.

The chalchihuitl is a stone which the old Spanish chroniclers are never tired of extolling. When Cortez landed at San Juan de Ulua, the first messengers sent by Montezuma brought with them "four chalchihuitls, a species of green stone of uncommon value, which is held in higher estimation with them than the smaragdus." So writes the chronicler Bernal Diaz, as translated by Lockhart. As a matter of course, supernatural powers were attributed to the stone; and indeed there is a legend which asserts that Quetzacoatl, the great lawgiver and high-priest of the ancient Mexicans, was begotten by a chalchihuitl placed in the bosom of the goddess Chimalma.

* "The Natural History of Jamaica," vol. ii. 1725, pp. 338, 339.

† "Nephrit und Jadeit, nach ihren mineralogischen Eigenschaften sowie nach ihrer urgeschichtlichen und ethnographischen Bedeutung." Stuttgart, 1875.

And what, after all, was this extraordinary stone—so wondrously endowed and so highly prized? This is a question which, in spite of all that has been written on the subject, has not yet, and perhaps never will be, answered with scientific accuracy. Some have described the chalchihuitl as a coarse emerald, others as a turquoise, others again as a jasper, and some finally as jade. Probably the term comprised a number of distinct minerals, having in common a green or greenish-blue colour, and including the jade-stone. Such at least seems to be the opinion of Mr. E. G. Squier, whose researches have thrown so much light upon American archæology.* That jade, or some kindred stone, was used by the ancient Mexicans seems certain from the specimens which have come down to us. Mr. Pumpelly, an American geologist, after describing a jade-like mineral from China, to which the name of *jadeite* is now given, goes on to say: "The chalchihuitl, a precious stone of the ancient Mexicans, as I have seen it in a mask preserved in the Museum of Practical Geology in London, and in several ornaments in the collection of Mr. Squier of New York, is apparently the same mineral."† The mask to which Mr. Pumpelly refers is figured in Plate VIII. fig. 1.

Since we are not aware that any jade, or jade-like mineral, occurs in Mexico, or as said before throughout America, it becomes an extremely interesting question to enquire whence the ancient inhabitants of Anahuac obtained their supply of the precious mineral. Did they procure it from the old world? If so, here is another link in the chain of evidence which points to early intercourse, at any rate to pre-Columbian communication, between the eastern and the western hemispheres. The home of the jade, so far as we know, is in the east rather than in the west; and the country in which it seems to have been longest used and most highly venerated is China.

By the Chinese, jade is generally known as *yu*; but it has been said that this is a generic name for a number of ornamental stones. Sometimes the word *chi* (or *stone*) is attached, and the jade is then referred to as *yu-chi*. Rémusat, whose *History of Khotan* was published in 1820,‡ discusses with great erudition the meaning of the word, and refers it to a very high antiquity. In the province of Yunnan, a particular kind of jade, to be hereafter noticed, is known as *fei-tsui*; while in Turkestan the jade-stone is called *yaschm*, a word which is

* "Observations on the Chalchihuitl of Mexico and Central America." By E. G. Squier, M.A. New York, 1869.

† "Geological Researches in China," etc. Smithsonian Contributions, 1866, p. 118.

‡ "Histoire de la Ville de Khotan, tirée des Annales de la Chine et traduite du Chinois."

also found in the form of *yeschl*, and is said to be cognate with ἴασπις, and therefore with our *jasper*. It has already been seen that jade was formerly regarded as a green jasper.

Jade is a stone of singular tenacity, breaking with difficulty and displaying a coarse splintery fracture. Notwithstanding the difficulty of cutting and polishing the stone, it has for ages been worked by the Chinese into a great variety of objects, such as vases, cups, armlets, bracelets, and other ornamental articles, often of most intricate patterns. These objects have always been very highly valued, on account not only of the beauty and rarity of the material, but also of the great amount of labour necessarily expended upon their production. This has led to numerous imitations of the Chinese yu-stone in glass or enamel known as *pâte de riz*.

It is said that when a piece of yu-stone of unusual size is discovered, the Emperor calls a council of artists to determine the form in which it may be most advantageously worked. On any important carving in jade the artist will spend at least twenty years, and in some cases his entire lifetime. When completed, the work is exposed to public criticism for a year, and if then pronounced satisfactory, the artist receives high honour and may be raised to the rank of a mandarin; but if the work is faulty he loses not only his reputation but his head.*

Probably the finest assemblage of objects ever made in yu, or Oriental jade, was the collection found at the Emperor of China's Summer Palace, Yuen-min-Yuen, at Pekin, when sacked in 1860. From this source a large number of specimens found their way to this country and to France. Some remarkable examples of jade-working may be seen in the South Kensington Museum, where there are two cases of fine carvings lent by Arthur Wells, Esq., of Nottingham. The colour of Oriental jade varies through a great variety of shades of green, but the stone is frequently of a milky white colour, very slightly tinged with a greenish yellow. While the white jade is generally uniform in tint, much of the green jade is mottled, or flecked with darker spots.

Among the more notable objects which the Chinese are fond of carving in yu-stone is the peculiar staff or wand of authority known as the *joo-ee*. One of these batons is represented in Pl. VIII. fig. 2. A joo-ee generally takes the form of a graceful double curve, something like the letter ᔓ, but with less pronounced curvature, and more like Hogarth's famous "line of beauty." It is only the finest of the joo-ees that are made of

* "Catalogue of Captain De Negroni's Collection of Chinese Porcelain, Jade," etc. 1865.

jade, others being carved in wood or in rock-crystal or even worked in metal. This instrument was formerly given by the Emperor to princes of state or to governors on taking official appointments, and was carried by them as an emblem of authority. It is now exchanged as a mark of friendship or expression of goodwill. The name signifies "As you wish," being a contraction of *Sze-sze-joo-ee*, or "everything according to your wish." The expanded end of a joo-ee generally bears a carving of the sacred lotus.*

Although jade is so highly prized in China, very little seems to be known about its occurrence in that Empire. It is said, however, that Chinese works on geography give a number of localities which have yielded the stone; and Mr. Pumpelly, whose work has previously been cited, describes the occurrence of a jade-like mineral—the jadeite of mineralogists—in the mountains of Southern Yunnan: the mineral is known locally as *fei-tsui*, and is "perhaps the most prized of all stones among the Chinese."

Whatever jade may be got in China itself, it is certain that the Chinese have relied for generations upon the quarries of Khotan for a large proportion of their raw material. As far back as 200 B.C., under the Han dynasty, the yu was regarded as the most costly production of Khotan. Marco Polo, who visited the country in the 13th century, refers to the occurrence of jasper and other ornamental stones between Yarkand and Khotan, whence he says they were imported into China.

Little, however, was known about the occurrence of jade in Turkestan until a few years ago, when the locality was visited by the brothers Schlagintweit—Hermann, Robert, and Adolph.† The quarries were afterwards described by the late Dr. Stoliczka, of the Geological Survey of India,‡ and by Dr. Cayley.§ We are now therefore in possession of accurate details as to the workings in this district—a district which has supplied the Chinese with more or less of their jade for the last two thousand years.

The old jade quarries are situated on the banks of the Karakash River, which flows down the southern slope of the

* "Catalogue of the Chinese Collection at Hyde Park Corner." By W. B. Langdon. 1844.

† "Ueber Nephrit nebst Jadeit und Saussurit in Künlün-Gebirge." Von Hermann von Schlagintweit-Sakünlünski. Sitzungsberichte der K. Bair. Akad. d. Wissensch, Munich, 1873, pp. 227–267.

‡ "On the occurrence of Jade in the Karakash Valley." "Quart. Journ. Geol. Soc.," vol. xxx. 1874, p. 568. "Rec. Geol. Surv. India," vol. vii. p. 51; and "Scientific Results of the Second Yarkand Mission," 1878, p. 18.

§ "The Jade Quarries of the Kuenlun": "Macmillan's Mag." vol. xxiv. 1871, p. 452.

Kuenluen mountains. Viewed from some little distance it looks as though a number of pigeon-holes had been irregularly hollowed out in the mountain-side. Of these excavations, Stoliczka found as many as 120. At the entrance to each working is a heap of fragments of jade and the minerals which occur in association with it—the refuse of former activity, for the quarries have been deserted for some years. The jade occurs in nests and veins, in gneissose and schistose rocks. Most of it is of pale colour, some nearly white; bright green jade being comparatively rare. It is interesting to learn from Schlagintweit that when the mineral is freshly broken from the rock, and while yet holding the "quarry water," it is so soft as to be readily scratched with a good knife, but that it gradually hardens on exposure to the atmosphere. The hardness of Oriental jade is about equal to that of felspar, and the hardness of jadeite, though slightly higher, never exceeds that of quartz.

After the expulsion of the Chinese from Yarkand, fifteen years ago, the quarries in the Karakash valley were deserted, and are now the retreat of the wolf and fox. Stoliczka remarks that if the quarries still remain unworked, if the people of Turkestan are too apathetic to quarry the stone and export it to China. the supply to the celestial carvers will probably become scant, and Oriental objects in jade will consequently become rare and valuable.

Pebbles of jade may be found in many of the streams which come down from the Kuenluen range, and it may therefore be concluded that the mineral is pretty widely distributed throughout this district. According to Schlagintweit it is not found in the Himalayas or in any part of India proper. Nevertheless jade, both in a raw state and carved into ornamental objects, is well known in India. Some remarkable specimens of jade from India, enriched with settings of brilliantly-coloured stones, were in the collection of the late Colonel Guthrie, and are now exhibited in the India Museum. It is difficult to find the precise source of the Indian-worked jade, the natives having merely a vague idea that it comes from a great distance. It appears certain, however, that jade or jadeite occurs in Burmah. None of the jade from Turkestan, it may be observed, can be referred to the species jadeite.

While referring to the occurrence of jade in Asia, mention should be made of the Siberian nephrite, which was first introduced to the western world at the International Exhibition of 1862. M. Alibert, who brought from Irkutsk such wonderful examples of graphite for the use of our lead-pencil makers, also brought some beautiful specimens of dark green jade. The mineral occurs in the form of boulders, embedded in a sandy soil, but is by no means common. The specimens brought by

Alibert were found in the Toonka range of the Sayan chain, in the Government of Irkutsk. There seems no reason why this beautiful mineral should not find its way from Eastern Siberia to the jade-loving Chinese.

While America has given to us, through its Spanish invaders, the word "jade," and Asia has furnished us with the finest examples of the stone worked into ornamental forms, we must turn to the islands of the Pacific Ocean for some of the most interesting applications of this material. When New Zealand was discovered, the natives were in the habit of using implements beautifully worked in a dark green stone, which they called in the Maori language, *punamu*, signifying "green-stone." So characteristic is the occurrence of this valuable material along the western coast of the South Island that the natives have given to this district the name of *Te Wahi Punamu*, or "Place of the Green-stone"—an expression which has been corrupted by some writers on mineralogy until it appears in one treatise under the curious guise of "Tawai Panama!" No doubt the name "punamu" is not used by the Maories with mineralogical precision, but includes a number of different minerals, and perhaps even rocks, all characterized by a more or less decided green colour, of which the most highly-prized is the true jade. This mineral occurs as pebbles, partly in the beds of rivers and partly along the sea-shore, and is also found *in situ*. By expenditure of prodigious labour, the natives work the intractable stone into axes and adzes, and especially into that peculiar weapon known as the *mere* or *pattoo-pattoo* (Pl. VIII. fig. 3). This is a short, flat, leaf-shaped hand-club, which is held by a thong passing through a hole in the handle, and securely bound round the wrist. It is only the great Maori chieftains who possess jade meres, the commoner forms of this weapon being made of less valued stones, and even of wood and bone. The jade meres are handed down from generation to generation as precious heirlooms, and are prized with superstitious veneration. Some excellent specimens of the mere may be seen in the Ethnographical Gallery in the British Museum, where some of the jade weapons show the effect of the intense heat to which they were exposed during the fire at the Government House in Auckland. Fig. 4, Pl. VIII., represents a singularly fine mere of jade seen by Hochstetter, the geologist on the exploring ship "Novara," in the possession of the mighty Maori chief, Te Heuheu.* General Lane Fox has called attention to the fact that the mere is used for prodding the enemy with its sharp end, and not for striking a blow, as with an ordinary club, since the latter act would endanger the weapon. Jade, it is true, is an uncommonly tough material; but it is

* "New Zealand," By Dr. F. von Hochstetter. Stuttgart, 1867, p. 362.

not every pattoo-pattoo which is made of so resistant a material, and those of more fragile stone might easily get shivered in a fray.*

Another favourite mode of applying jade in New Zealand is to carve it into the curious ornament or amulet, known as *Hei Tiki*. This ornament, which is worn upon the breasts by Maori chieftains, presents the form of a grotesque human figure, generally having its huge eyes inlaid with the iridescent shell of *Haliotis*, and sometimes of late years with sealing-wax, the red wax contrasting strongly with the green-stone. Fig. 5, Pl. VIII. represents one of these figures. From the fact that the lower edge of the tiki is always sharp, General Lane Fox infers that it may have been derived from the type of the celt.

Jade is likewise a favourite material with the natives of New Caledonia, who find it in their island, and fashion it into various kinds of axe-heads. It also occurs in some of the other islands of the Pacific Ocean.

No jade has ever been recorded from Africa, and it is extremely doubtful whether it occurs in Europe. It is said to have been found in the form of boulders at Potsdam near Berlin, and at Schwemsal near Leipzig. It remains, however, uncertain whence the mineral was originally derived, and whether it had been transported by natural or by human agency. In the Great Exhibition of 1851 there was a large mass of pale green jade, reputed to have come from Turkey; but nothing more was known of its origin, and its existence probably does not vitiate the general statement that no true jade or jadeite has yet been found *in situ* in Europe.

But although jade is not now known to occur in this quarter of the world, it was used by some of the early inhabitants of Europe in prehistoric times. Small celts of jade are occasionally found in the tumuli of Brittany, and in some other parts of France; while they are familiar enough to the explorers of the pile dwellings in the lakes of Switzerland.† It seems, however, that the material was regarded as of great value, even in early times, for these implements are comparatively rare. Thus among the hundreds of stone celts found in the settlement of Lüscherz, on the Lake of Bienne, only about thirty are of jade and jadeite. Still, the presence of this material, even in a solitary example, is sufficient to raise the perplexing question, How did the men who reared such curious structures in the Swiss lakes manage to secure a material for which they might

* "Note on the Use of the New Zealand Mere." "Journ. Ethnolog. Soc." New Series, vol. ii., 1870, p. 106.

† See Dr. J. E. Lee's translation of Keller's "Lake Dwellings," 2 vols. Second Edition, 1878.

seek in vain throughout the length and breadth of Europe? Did they obtain it by barter with people from the East—by early intercourse with China, or Turkestan, or Siberia—or did the old lake-dwellers, when driven westwards from their Asiatic homes, bring with them their much-valued implements of jade?

As a remarkable example of an archaic implement in jade, attention may be called to an unique celt which was brought from Egypt many years ago by Captain Milner, and is now in the Christy Collection. The peculiarity of this implement lies in the fact that it bears upon its two faces Gnostic inscriptions neatly engraved in Greek characters. The general appearance of the celt, and the mode in which the inscription is incised—on one side in eight lines, on the other side in eighteen leaves upon a spiral axis—are sufficiently shown in figs. 6 and 7, Pl. VIII. It is believed that the engraving was executed at Alexandria during the third or fourth century of our era; but the celt itself is no doubt of much older date. Supposing it to have been picked up, the fortunate finder would regard it, in accordance with early opinion on such objects, as a ceraunia, or thunderbolt—a holy thing fallen from Jupiter—on which a mystic formula might appropriately be engraved, with the advantage of making the spell doubly potent.*

Although this remarkable specimen was found in Egypt, we are not aware that the ancient Egyptians ever employed jade as the material on which to exercise their glyptic art. It is true that some authorities have referred to jade as *pietra d'Egitto*,† but there is here probably some mistake in the identification of the stone. Egyptian amulets and sepulchral ornaments are not unfrequently wrought in green stones, but these are mostly either jasper or felspar. The latter is the material now called *Amazon stone*; but it should be noted that many of the older writers refer to jade under this name, whence it has been inferred that jade occurs in South America.

All modern mineralogists, however, restrict the term Amazonite to an apple-green felspar, which until lately was referred to the species *Orthoclase*, but which has recently been shown by Des Cloizeaux to be a variety of *Microcline*. At the present time the finest Amazon stone comes, not from the Amazons, but from Siberia, Labrador, and Colorado. It is uncertain, however, whence the Egyptians derived the green felspar which they employed. This felspar was used also by the Assyrians, who occasionally worked it into the well-known

* "On a Ceraunia of Jade converted into a Gnostic Talisman," by C. W. King, M.A. "Archæolog. Journ.," vol. xxv. 1868, p. 103.

† Blumenbach, e.g. in his "Handbuch d. Naturgeschichte," 1797.

cylindrical seals which are so exquisitely engraved with figures and arrow-headed inscriptions. It appears, however, that jade was likewise used by the Assyrian engravers, for there is at least one cylinder in the British Museum which is described as being of this material.

On the whole, then, it appears that jade, though unquestionably employed by prehistoric man in Western Europe, was but little known in the great centres of early civilization in the East. By Greek and Roman artists the material was rarely, if ever, used; the engraved celt, already referred to, being a solitary example of Greek engraving, and only upon a stone which had been worked into shape by an earlier and a foreign hand. Nor was the material used, so far as we know, by mediæval artists. Indeed, Mr. King, the great authority on antique gems, after referring to the introduction of jade on the Spanish conquest of America, says: "Even had the jade been known at an earlier period, the ancient love of the beautiful and their correct taste would have prevented their throwing away their labour and time upon so ugly and refractory a material." *

If so unfavourable an opinion is shared by other connoisseurs, though assuredly no lover of Oriental art will join in the condemnation, it is no wonder that jade has not been used in modern times by European artists. Of late, however, a small quantity of a beautiful green variety of jade has been imported in the rough from New Zealand, and has been cut and polished both in this country and in Germany into the form of ear-drops and other trivial objects of personal ornament.

It will have been gathered from the foregoing part of this article that the term jade has been vaguely applied to a number of different mineral-substances more or less akin in their physical properties, and all capable of being used for ornamental purposes. Even the most experienced mineralogists have, until within the last few years, included under this term two or three substances which agree in possessing various shades of green colour, and in having an extreme toughness, but which differ widely in chemical composition. It is desirable, before closing this article, to clearly differentiate these several minerals.

In 1846 M. Damour published an analysis of a piece of the well-known whitish Oriental jade, which had been carved in India.† From his analysis he concluded that this kind of jade was essentially a silicate of magnesium and calcium, and might be regarded as a form of hornblende, comparable with the

* "Antique Gems," by the Rev. C. W. King, M.A., 1860, p. 98.

† "Analyse du Jade Oriental; réunion de cette substance à la Trémolite." "Annales de Chimie et Physique," sér. iii. t. 16, 1846, p. 469.

variety called, from the Swiss valley of Tremola, *Tremolite.* Subsequent analyses of some of the dark green jade of New Zealand have shown that this also may have a similar composition, and may be referred to the green variety of hornblende called, from the radiated structure which it characteristically presents, *Actinolite.* Both these kinds of jade are therefore hornblendic or amphibolic minerals, similar in chemical composition to well-known minerals occurring abundantly in Europe and elsewhere, but differing from them in certain physical characteristics. No forms of tremolite or of actinolite are known in Europe to which the designation of jade can fairly be applied.

The specific gravity of this hornblendic jade, distinguished by Damour as *Oriental Jade*, is about 3. Mr. T. Davies, of the British Museum, who has determined the density of upwards of a hundred specimens from New Zealand, gives the limits between 3·00 and 3·02.* It may seem trivial to dwell upon this point, but it will be presently seen that specific gravity offers a valuable means of diagnosing the jades.

Some other examples of New Zealand jade examined by Damour yielded very different proportions of lime and magnesia, and the analyses lead to a formula more like that of augite or pyroxene than of hornblende. In physical properties it closely resembles the Oriental variety, but differs in having a specific gravity of about 3·18. It appears to be a rare mineral, and as it is known only from New Zealand and the Marquesas Islands, it has been distinguished as *Oceanic Jade.*† It must not be forgotten, however, that most of the jade of the Pacific Islands belongs to the hornblendic and not to the augitic form.

On examining a sample of green jade, about sixteen years ago, M. Damour found so great a difference in its composition from that of either the Oriental or the Oceanic nephrite, that he proposed to regard it as a distinct mineral under the name of *Jadeite.*‡ It is a silicate of aluminium, sodium, calcium, magnesium, &c. Its specific gravity varies between 3·28 and 3·35, and is therefore higher than that of jade: it is also harder, and hence jadeite will scratch a piece of ordinary jade. Damour placed this mineral near to Wernerite. It is this substance which, as mentioned above, occurs in Yunnan, and is known as *feit-sue.* Many of the celts found in Brittany and in

* "Notes on Jadeite and Jade." By Thomas Davies, Esq., F.G.S. Appendix to Lee's translation of Keller's "Lake Dwellings," 2nd ed. vol. i. p. 683.

† "Sur la composition des haches en pierre trouvées dans les monuments celtiques et chez les tribus sauvages." Par M. Damour. Part II. "Comptes Rendus," t. lxi. 1865, p. 357.

‡ "Notice et analyse sur le Jade vert: réunion de cette matière minérale à la famille des Wernerites." "Comptes Rendus," t. lvi. 1863, p. 861.

the Swiss lake-dwellings are composed of this substance. No jadeite, however, has been found *in situ* in Europe. For numerous analyses of jade and jadeite we are indebted to Herr L. R. Von Fellenberg, whose work has been of especial interest in connection with the materials used by the lake-dwellers of Switzerland.*

Under the name of *Jade tenace* the French mineralogist Häuy described a mineral which was considered by the elder De Saussure to be a variety of jade. It was afterwards regarded by mineralogists as a distinct mineral, and was termed by the younger De Saussure (in honour of his father) *Saussurite*, a name which still holds its place in scientific nomenclature. This mineral is in many ways curiously like jadeite: its specific gravity, for example, is between 3·2 and 3·42, its hardness is about equal to that of quartz, and it is equally rich in alumina. Its chemical composition, however, brings it close to *zoosite* or *lime-epidote*. Some of the so-called jade of Turkestan is found to be Saussurite, and this mineral is also the substance in which many of the Swiss celts are wrought. In the form of boulders brought down by glacial action from the Swiss Alps, it is scattered widely through some of the Alpine valleys, and is abundant in the country around the Lake of Geneva. Pebbles of this tough material, picked up by the pile-builders on the marge of the lakes in which they dwelt, would naturally attract attention, and be utilized as a valuable material for implements and weapons. No wonder then that celts of Saussurite are found in the relics of these primitive habitations. If this mineral be admitted to rank with the jades, it will, of course, contradict the assertion that no jade occurs in Europe; and it is for this reason that the expression "true jade" has often been used in this article.

Before leaving the subject, it may be useful to cite a few analyses of jade, and of kindred minerals commonly called jade:—

	I.	II.	III.	IV.	V.	VI.
Silica . .	57·60	51·70	52·25	59·17	58·62	43·59
Magnesia .	25·61	23·50	18·07	1·15	2·23	2·98
Ferrous oxide	·66	7·62	6·80	1·56	1·86	—
Ferric oxide.	—	—	—	—	—	2·61
Lime . .	12·68	13·09	19·27	2·68	3·85	19·71
Soda . .	—	—	·68	12·93	11·64	3·08
Alumina .	·25	·65	·58	22·58	21·77	27·72
Water, etc. .	2·74	2·42	1·50	—	—	·35
	99·54	98·98	99·15	100·07	99·97	100·04

* See, for example, the "Neues Jahrbuch für Mineralogie," 1865, p. 619.

I.	White Oriental Jade from China . .	sp. gr. 2·97
II.	Green Oriental Jade from New Zealand . . .	3·015
III.	Oceanic Jade from New Zealand	3·18
IV.	Jadeite from China	3·34
V.	Jadeite from a celt found at Morbihan, France . .	3·344
VI.	Saussurite from L. Geneva	3·4

In addition to the minerals enumerated in this table, there are a few other substances which have occasionally been classed as jade. Thus, a mineral found at Rhode Island was formerly described as an American nephrite, but has been found on analysis to be only a very hard variety of serpentine, and is now distinguished as *Bowenite*. Many of the celts from Brittany are wrought in a material known as *Fibrolite*, which is a simple silicate of aluminium, but has been mistaken for jade. Again, a dark-coloured jade-like mineral, occasionally used for implements, is distinguished by Damour as *Chloromelanite*; this is a ferric-aluminic silicate, notable for high specific gravity, which ranges from 3·4 to 3·6. *Jasper*, when of dark green colour, has not unfrequently been taken for jade; but it need hardly be said that, though the two substances do not differ widely in their degrees of hardness, they are extremely different in density. As the specific gravity of jasper is only about 2·6, we have an unfailing test by which it may be distinguished from every kind of jade.

Excluding, however, such substances as jasper, which obviously have no right to claim a place in the jade family, there yet remains a number of ornamental stones which have been, and are still, popularly grouped together under the inclusive name of jade. Much as the mineralogist may desire to see these substances rigidly designated by their proper names, it must be borne in mind that their discrimination is by no means an easy task, especially to unscientific collectors of works of art, into whose hands the finest specimens usually fall. Specific gravity offers, perhaps, the easiest and surest means of diagnosis; but to determine specific gravity is not always convenient, and may be impossible, as in the case of jade objects mounted in metal. Chemical examination is, of course, out of the question in ninety-nine cases out of a hundred. Hence it sometimes becomes difficult even for a mineralogist to determine with precision the real mineralogical nature of a given specimen. It is then that a vague name like jade may still be retained with advantage, its value depending, in fact, upon its very vagueness. Even the greatest stickler for scientific precision must admit that there are occasions when he is compelled to lay aside his scruples, and to make a ruthless sacrifice of Accuracy on the altar of Convenience.

EXPLANATION OF PLATE VIII.

FIG. 1. Ancient Mexican Mask in Jadeite, probably an example of the Chalchihuitl, now in the Museum of Practical Geology. Natural size.

„ 2. A Joo-ee, or Chinese wand of authority, carved in Oriental jade.

„ 3. Mere, or patoo-patoo, carved by the Maories of New Zealand in jade, known as punamu.

„ 4. Mere in punamu, curiously ornamented, belonging to a Maori chieftain, Te Heuheu.

„ 5. Hei-tiki, or Maori amulet, worn upon the breast ; carved in jade or punamu. Half size, linear.

„ 6 & 7. A jade celt, or ceraunia, with Gnostic inscription in Greek characters upon the two faces ; found in Egypt, and now in the Christy Collection of the British Museum.

REPORT ON AMERICAN DREDGINGS IN THE CARIBBEAN SEA.

By ALEXANDER AGASSIZ.*

I JOINED the *Blake* at Washington, on November 27, 1878, for a second dredging cruise. According to your instructions, we intended to proceed to Nassau, and there devote a few days to dredging and sounding, in order to trace the connection between the fauna of the northern extremity of the Bahama Banks and that of the Straits of Florida. Owing to rough weather this was not deemed prudent, and we were compelled to put into St. Helena Sound, and, for the same reason, when off Jupiter Inlet, instead of crossing the Gulf Stream to make Nassau, it was thought best to put into Key West. From there, when the weather moderated, we started from Kingston, Jamaica, calling at Havana for the purpose of making a couple of hauls on the Pentacrinus ground discovered by Captain Sigsbee off Morro Light. We made two casts of the dredge in 175 to 400 fathoms, and obtained a few specimens of Pentacrinus. We kept on along the northern shore of Cuba, through the Old Bahama Channel, without stopping to sound or dredge, Mr. Pourtalès having in former years dredged and sounded, in the *Bibb*, Acting Master Platt, U.S.N., over the greater part of this line.

At the eastern end of the Old Bahama Channel we ran a line of dredgings and soundings across from Caya Crux to Lobos Light. In the deepest part of the channel we found only 500 fathoms, although the hydrographic maps indicated 900 fathoms; no bottom. This is an excellent example of the uncertainty of the old method of sounding with hemp rope, even in moderately deep water, when there is a strong current, such as we found here.

* The following report of the dredging operations of the U. S. Survey steamer *Blake*, during the winter of 1878–79, contains so great an amount of interesting information that we have thought it well worth reprinting for the benefit of the readers of the "POPULAR SCIENCE REVIEW."

Nothing of special interest came up in any of the casts made either with the trawl or dredge. Wound around the steel-wire rope on this line, however, we found a few pieces of the deep-sea Siphonophores (Rhizophysa), described lately by Studer in the "Zeitschrift für wissensch. Zoologie." Subsequently we frequently found more or less complete specimens of these Siphonophores, generally entangled on the wire rope or attached to the trap of the trawl. Studer gives a long list of the depths from which they came up attached to the sounding line, but it is by no means certain that these Siphonophores belonged to the depths indicated by the wire. They may have become caught on the wire while it was reeling in at only a short distance from the surface.* The fact that Studer never succeeded in bringing up any of these species in the tow-net, even when lowered to a considerable depth, is as little conclusive, since, at any rate in the Caribbean Sea, their isolated parts and fragments are not uncommon floating on the surface. It is probable that they usually live at a certain depth below the surface, and some of them may, like Cassiopea, prefer to dwell near the bottom; but until we possess a net so constructed as to give some sure indication of the intermediate depths at which the animals living at various distances between the surface and bottom have been gathered in, it seems hazardous to define the bathymetrical range of a large number of pelagic animals, such as the Acalephs, Siphonopores, Heteropods, Pteropods, numerous Foraminifera, Radiolaria, and the like, the habits of which are scarcely known.

In the case of fishes, when dredging in deep water at a moderate distance from the land, we ought not to take it for granted that they invariably live at the depth to which the trawl may have been lowered. The young of many of the deep-water fishes are undoubtedly pelagic, often till a late period of growth; and thus many of the deep-water fishes have probably come to light, especially in the proximity of oceanic islands, or along coasts situated near deep water. We made three casts off the coast of Cuba between Nuevitas and Cape Maysi. In lat. 21° 2′ N., long. 74° 44′ W., off Cay de Moa, in 1,554 fathoms, we found a patch of green sand, made up of large Globigerinæ, similar to that mentioned by Mr. Pourtalès in his "Deep-Sea Corals."

We also obtained, in 994 fathoms, off Nuevitas, large blocks of genuine white chalk, composed mainly of Globigerinæ and

* In one case, dredging in 1,000 fathoms, numerous fragments of a Rhizophysa came up after drawing in 100 fathoms of wire! On another occasion, the same species came up after drawing in 300 fathoms, while dredging in 500 fathoms.

Rotalinæ. Large quantities of ooze and white clay, which proved to be only the white chalk in different stages of compression, also came up in the trawl. If the conditions now existing at that depth at all resemble those of the time of the white chalk, I could readily understand how perfectly sea-urchins or molluscs would be preserved if once enclosed in this homogeneous substance, to be gradually compressed into solid white chalk.

In one of the hauls taken between Cape Maysi and Jamaica (1,200 fathoms), we obtained the first specimens of Phormosoma I had seen alive. I was much astonished to find them, fully blown up, hemispherical or globular in shape. This was the shape they always took in subsequent hauls, and on several occasions, when they were obtained from comparatively shallow water, near the 100 fathom line, they came up fully alive and retained their globular outline. The alcoholic specimens I had seen in the *Challenger* collections came up as flat as pocket-handkerchiefs, from great depths, and were naturally regarded as flat sea-urchins, although of course endowed with great mobility of test. These Echini, with their globular flexible tests, recall vividly the Perischoechinidæ, with which they have also points of resemblance of great interest in the structure of their ambulacral and interambulacral plates.

In the dredgings taken off the south-eastern end of Jamaica, we did not bring up anything of great importance. From Jamaica we were obliged, owing to the strong trades, to keep on towards St. Thomas, without either sounding or trawling, till off Porto Rico. During the winter months the trades blow sufficiently hard to make dredging and sounding quite uncomfortable on a vessel of the size of the *Blake*. We had, therefore, no opportunity of adding anything to the hydrography of that part of the Caribbean Sea.

On arriving at St. Thomas's we made a programme for our season's work. This we were fortunate enough to carry out to the letter, as far as the dredging and sounding were concerned. With the exception of the time required for coaling and overhauling the engine at Martinique and St. Lucia, not a single day was lost. Although Lieutenant-Commander Sigsbee, U.S.N., did not command the *Blake*, yet the improvements which were made this year in the dredging and sounding apparatus were all carried out under his supervision, the vessel having been fitted out for sea before he was relieved by Commander J. R. Bartlett, U.S.N., who commanded the *Blake* during this winter. It was also my good fortune to find on board the majority of the officers with whom I sailed in the winter of 1877–78. We thus started under the very best auspices. In the use of the improved machinery, suggested by our former cruise, the ex-

perience of the old officers saved us from the annoyances which always accompany the introduction of new methods. The *Blake* was this year provided with a new double-cylinder reeling-engine, built by Copeland and Bacon, placed at right angles to the reel, on which our steel rope was wound. A small double engine revolved the reel, so that the wire rope was wound independently of the main reeling-engine. The wire rope was led to the port side directly from the main reeling-engine, then by a large wrought-iron sheave along the deck to the mainmast, thence across to the starboard side, and then along the deck to the reel, upon which it was wound. This worked admirably, relieving the reel, which thus became a mere spool, from all strain either in winding up or in dredging, the whole strain being taken up by the ten turns of the wire rope on the surging drum of the main reeling-engine. The arrangements for leading off the wire from the bow of the ship, through a large sheave at the end of the dredging-boom, were practically the same as last year. The steel spring accumulator was, however, replaced this year by one of car-rubber springs, suspended along the foremast, and to this accumulator was attached the pendant, running along the dredging-boom which carried the dredging-pulley. As Lieutenant-Commander Sigsbee is soon to publish, in one of the Coast Survey Reports, a full account of the dredging and sounding apparatus used on board the *Blake*, I will not speak in greater detail of our apparatus.

No change was made in our dredges. In the trawls several new forms were tried, but we found that the most satisfactory trawl was of the shape adopted last year, the only important change being the greater height of the runners—30 inches. The bar connecting the runners was used as a frame to stretch a sheet of netting across the whole beam, so as to divide the trawl opening into two halves, each opening into the trap. This enabled us to give a longer lead line to the mouth of the double trawl, without the danger of fouling from the lead line of the other side. The only change I could still suggest would be that this lead line should run through rings at the corners of the runners; the strain on the side which fell on the ground would take up the slack of the upper side, and thus increase still further the sweep of the trawl. Our trawl-nets were made much shorter than last year, and for deep work, when so much ooze is always likely to choke the trawl, it would be advisable for a ten-foot beam to have a net of not more than twelve to fifteen feet in length.

We also tried dragging a heavy tow-net rapidly over the ground at great depths, in hopes of catching the more active crustacea and fishes; but we found that, after all, no deep-sea machine worked better than a trawl, which, when moved rapidly

over the ground, at the rate sometimes of two to two and a-half miles an hour, invariably brought up a fine harvest of fishes and crustacea, in addition to the usual contents of the sedentary and more sluggish forms. Although the deep-sea tow-net was used several times, we never brought up any of the so-called deep-sea Siphonophora of Studer, even in localities where they came up on the wire rope.

Captain Sigsbee's new sounding machine worked admirably, and he has every reason to be entirely satisfied with the improvements he has made upon his former machine.

We carried 6,000 fathoms of new galvanized steel-wire rope $1\frac{1}{16}$ inch in circumference made by the Roebling Sons' Company, which, owing to its greater pliability, proved even more satisfactory than the wire rope used on the last cruise. The steel-wire rope continued during our whole cruise to give complete satisfaction, and enabled us, as in the previous year, to work with the greatest possible rapidity consistent with safety and with the proper handling of the trawls and dredges.

We usually lowered in deep water at the rate of four to four and a-half or five minutes per 100 fathoms, and reeled in at the same rate. In the many places where we found rough or rocky bottom we used a flat bar of six-foot beam, to which rings were attached for fastening tangles and a shot. This bar, with from a dozen to fifteen bundles of tangles, proved perhaps our most effective machine in rough bottoms. It rarely fouled, as the dredges or trawls are so apt to do, when working over unfavourable ground. The region over which we chiefly worked this year extended from St. Thomas to Trinidad. Over a limited area like this it was possible to cover the ground very satisfactorily. The work done off the principal islands began usually at the 100-fathom line, and extended into the deepest water off the lee side of the Caribbean Islands. But little could be done in the way of dredging in the passages between the islands or to the windward of them, owing to the strong trades. While working off Barbadoes we undoubtedly obtained a fair representation of the fauna to the windward of the Caribbean Islands, which does not seem to differ from that of the lee side.

During this season we occupied no less than 200 stations, and made over 230 hauls from the 100-fathom line to the depth of 2,412 fathoms. A few hauls were occasionally made in shallow water, but they formed no part of our regular scheme. Although we have obtained from the West India Islands some of the most interesting invertebrates, yet we did not find the fauna of the eastern extremity of the Caribbean Sea materially different from that of the Gulf of Mexico and the Straits of Florida. It certainly is by no means as rich in animal life at

great depths. We rarely got from deep water, say between 1,500 and 2,400 fathoms, the rich hauls so invariably made in the Gulf from depths of between 1,200 and 2,000 fathoms. But we found, what was much more important for our success, that the range of the greater number of deep-sea species extended within very easy dredging limits, and we soon discovered that by dredging mainly between 300 and 1,000 fathoms we not only obtained nearly all the species extending to the 2,000-fathom line, but obtained them in considerable numbers. This enabled us, of course, to collect a large amount of material, and the collections of this year's cruise, combined with those of the previous year, added to the older collections made by Count Pourtalès on the *Bibb* and to those of the *Hassler*, make our deep-sea collections but little inferior to those of the *Challenger*.

I was greatly struck with the large number of our species, which, if not identical, are at least closely allied to those brought home by the *Challenger*; and I was specially disappointed at the absence of types not already collected by the great English expedition. I think it can be fairly stated that the great outlines of the deep-sea fauna are now known, and that, although many interesting forms will undoubtedly be dredged in the shallower waters, between 100 and 300 fathoms, we can hardly expect to add materially to the types discovered by the dredging expeditions of the last ten years. As has been well said by Mr. Moseley, of the *Challenger*, it becomes somewhat monotonous to find constantly the same associations of invertebrates in the deeper hauls, and it is only in shallower waters that it is possible to keep up one's enthusiasm after a few months' work. I should be inclined, from the experience of the past two years, to carry the range of the deep-sea fauna as high as 300 or 350 fathoms, and to call the littoral fauna the species extending mainly to the 100 or 150-fathom line; from the 100 to the 300 or 400-fathom line extend the species which are neither littoral nor yet have the wide geographical range belonging to species found beyond that depth. But this upper limit of the deep-sea fauna must, of course, depend upon the temperature, and undoubtedly varies greatly from local or partly local causes.

While dredging to the leeward of the Caribbean Islands we could not fail to notice the large accumulations of vegetable matter and of land *débris* brought up from deep water many miles from the shore. It was not an uncommon thing to find at a depth of over 1,000 fathoms, ten or fifteen miles from land, masses of leaves, pieces of bamboo, of sugarcane, dead land shells, and other land *débris*, which are undoubtedly all blown out to sea by the prevailing trade-winds. We frequently found floating on the surface masses of vegetation, more or less water-

logged and ready to sink. The contents of some of our trawls would certainly have puzzled a palæontologist; between the deep-water forms of crustacea, annelids, fishes, echinoderms, sponges, etc., and the mango and orange leaves mingled with branches of bamboo, nutmegs, land shells, both animal and vegetable forms being in such profusion, he would have found it difficult to decide whether he had to deal with a marine or a land fauna. Such a haul from some fossil deposit would naturally be explained as representing a shallow estuary surrounded by forests, and yet the depth might have been 1,500 fathoms. This large amount of vegetable matter, thus carried out to sea, seems to have a material effect in increasing, in certain localities, the number of marine forms.

The collections made have all arrived in Cambridge, and will be sent for determination, as fast as practicable, to the naturalists who have undertaken the reports on the different groups of last year's collections. As their preliminary reports are well under way, I need only allude here in general to some of the most interesting types. Among the Foraminifera are a number of the arenaceous types noticed by Mr. Brady, in the collections of the *Challenger* and *Porcupine*; among the Sponges, a species allied to Phoronema, a small Hyalonema, tufts of large, siliceous spicules (Hyalonema proper), covered at one end with Zoanthus, very similar to the common Japanese type; fine series of Dactylocalyx, showing the mode of growth from a simple globular form; and a gigantic Euplectella. The collection of Starfishes was quite small, and contained nothing worthy of special notice. The collection of Holothurians contained, in addition to the deep-sea forms mentioned in my former letters, a larger number of species than last year, genera allied to Molpadia, Caudina, Echinocucumis, and the like.

Among the Echini, with the exception of the Pourtalesia group, all the types collected by the *Challenger* are well represented, with a few Spatangoids hitherto unknown. The number of Echinothuriæ was quite large. Of the Pourtalesia group but few specimens in good condition were obtained, though the trawl brought up numerous fragments of several of the genera (if I am not mistaken) collected by the *Challenger* in deep waters in the Southern Ocean. The small number of Clypeastroids collected, even when approaching the South American shore, at the 100-fathom line, near Trinidad, where they are so common, shows pretty conclusively that the group, with the exception of Echinocyamus, is an eminently littoral one. A large collection of Comatulæ was made, and a number of specimens of Rhizocrinus were obtained, but only a few were in perfect condition. Of Holopus only a part of a specimen was found. It was collected off Montserrat, and escaped my atten-

tion; although, of course, on the look-out for black Holopus, I did not notice this imperfect whitish specimen, which must have been alive, among the numerous Pentacrini with which it came up. Our collection of Pentacrini is quite extensive; we found them at Montserrat, St. Vincent, Grenada, Guadeloupe, and Barbadoes, in several places, in such numbers that on one occasion we brought up no less than 124 at a single haul of the bar and tangles. We must, of course, have swept over actual forests of Pentacrini crowded together much as we find the fossil Pentacrini on slabs. Our series is now sufficiently extensive to settle satisfactorily the number of species of the genus found in the West Indies. There are undoubtedly the two species which have thus far been recognized. It is evident that they vary greatly in appearance, *P. Müller*i being the most variable. I have nothing to add to the general description of their movements given by Captain Sigsbee in my second letter, with the exception of their use of the cirri placed along the stem. These they move more rapidly than the arms, and use them as hooks to catch hold of neighbouring objects, and, on account of their sharp extremities, they are well adapted to retain their hold. The stem itself passes slowly from a rigid vertical attitude to a curved or even drooping position. We did not bring up a single specimen showing the mode of attachment of the stem. Several naturalists, on the evidence of large slabs containing fossil Pentacrini, where no basal attachment could be seen, have come to the conclusion that Pentacrini might be free, attaching themselves temporarily by the cirri of the stem, much as Comatulæ do. I am informed, however, by Captain E. Cole, of the telegraph steamer *Investigator*, that he has frequently brought up the West India telegraph cable on which Pentacrini were attached, and that they are fixed, the basal extremity of the stem spreading slightly, somewhat after the manner of Holopus, so that it requires considerable strength to detach them.

The collection of Ophiurans is perhaps the largest ever made. They seem to play a very important part in determining the facies of a fauna. They occur everywhere, at all depths, and often in countless numbers. I hardly think we made a single haul which did not contain an Ophiuran. They often came up when the trawl brought nothing else. In some places the bottom must have been paved with them, just as the shallows are sometimes paved with Starfishes and Echini, and many species hitherto considered as extremely rare are found to be really abundant. Most, or perhaps all, the deep sea Atlantic species obtained by the *Challenger* have been re-discovered in large numbers. Such rare species as *Sigsbeia murrhina*, *Ophiozona nivea*, *Hemieuryale pustulata*, and *Ophiocanax hystrix*, were found in plenty. Among the representatives of northern seas

may be cited *Astronyx Loveni* (?) while a single specimen of Ophiophyllum represents the great rarities. Of *Astrocnida isidis*, of which only three specimens were known, we have half a dozen. A large Pectinura recalls the shallow fauna of the East Indies; while a new Ophiernus brings to mind the Antarctic deep-sea forms. Finally, the supposed abundance of simple-armed Astrophytons is fully confirmed by the various species of Astrochema, and by a new species of Ophiocreas.

The diligent search of Count Pourtalès in the Straits of Florida, the *Hassler* expedition, the *Challenger* explorations, and the two expeditions of the *Blake*, have evidently brought up the majority of the species of Ophiurans; for among the enormous mass of specimens this time obtained, the number of new species is not very great.

The Hydroids and Bryozoa were mainly represented by the same forms as those collected last year, or in former coast survey expeditions in the Florida Straits.

The corals, although abundant in specimens and species, probably contain but few undescribed ones. Very fine specimens of the larger, simple corals obtained by the *Challenger* expedition, which were never found in our earlier dredgings in the Gulf of Mexico, or the Straits of Florida, were dredged here, such as Flabellum, Trochocyathus, Ceratotrochus, etc. Several of the deep-sea Actiniæ, described by Moseley, were obtained, generally attached to sponge spicules, Gorgoniæ, or stems of Umbellariæ.

The Alcyonarians were also very abundant, and among them we expect to find many novelties. Little can be said of them at first view, as the deep-water forms have thus far received but little attention. One form, growing in a regular spiral, with equidistant branchlets on the outer side of the spire, seems, by this mode of growth, to differ from anything previously known in that order. Several fine specimens of Umbellaria were obtained.

Among the Annelids, the tubicolous Annelids are by far the most striking, from the exquisite beauty of their tubes, composed of siliceous spicules, and dead Pteropod shells, and from their strange associations with Corals, Gorgoniæ, sponges, and even molluscs. A species of Phorus was frequently accompanied by a large Annelid, comfortably established in the axis of the shell, with the head close to the aperture.

Among the crustacea we found again the *Bathynomus giganteus*, A. M. Edw., discovered last year. We also brought up from 734 fathoms a Pycnogonum, measuring not less than two feet along the legs, when fully extended; a fine *Astacus zealacus*; and, from 416 fathoms, a magnificent species, allied to Nephrops, blind, but with rudimentary eye-stalks. An in-

teresting isopod, with gigantic lateral processes on the posterior segment, was also obtained from 300 fathoms. Many hermit-crabs occupied tubes of bamboo or cavities in dead wood and sponges, of which they completely closed the orifice, with one of the large claws flattened like the operculum of a Serpula.

Among the molluscs, the preliminary report of Mr. Dall (in Letter No. 2), mentions the most important types. We obtained, however, in addition, a good set of Pleurotomaria, one specimen measuring five inches in height, while another was so small that the slit, from which the genus takes its name, existed only as a slight indentation. I hope to supply Mr. Dall with the material necessary for an anatomy of this interesting genus. But by far the most interesting of the molluscs is a Spirula, from a depth of 950 fathoms, in excellent condition. The small number of Waldheimia collected this year is quite striking; other species of Terebratulæ were more common. We found, as was usual last year, an immense number of dead Pteropod shells at all depths, playing a most important part in determining the nature of the deep-sea bottom.

The collection of fishes is excellent; its special characteristic is the large number of Lophioid types it contains. We also obtained many of the genera collected by the *Challenger*. Some of the rarer pelagic fishes, which are occasionally caught at sea, are undoubtedly either full-grown deep-sea fishes or their young. It becomes an interesting problem to know where the young remain, before they become permanently inhabitants of deep water.

The pelagic fauna of the eastern part of the Caribbean Sea is, during the winter season, rather scanty. Owing to the constant agitation of the water, I had no opportunity, as in the Gulf, to make much use of the surface tow-net. From the number of fragments of Siphonophora constantly found they must be very numerous. In the roadstead, under the lee of the islands, there was but little pelagic life to be found. Everything either remains at a short distance below the surface, or is blown out to seaward of the islands. The phosphorescence, in consequence, is far less brilliant than in the Gulf of Mexico, although occasionally the masses of Ctenophora (a species of Mnemiopsis), swimming at different depths, produce a very striking illumination; sudden flashes of light suddenly appearing as if coming from great balls of fire floating a short distance below the surface. The most striking phosphorescent phenomena were produced by a small Annelid, allied to Syllis, which moved over the surface of the water with great rapidity, performing the most remarkable gyrations, and tracing its path, which remained phosphorescent for a short time, by a brilliant line of light. Among the deep-water forms, several of the

species of Gorgonia and Antipathes (especially Rüsea), showed a bright bluish phosphorescence when coming up in the trawl. One Ophiuran also, like one of the Mediterranean species mentioned by Panceri, was exceedingly phosphorescent, emitting along the whole length of its arms at the joints a brilliant bluish-green light.

One of the most interesting results reached by this year's cruise is the light thrown upon the former extension of the South American continent, by the soundings taken while dredging, and those subsequently made in the passages between the islands by Commander Bartlett. These, together with the soundings already known, enable us to trace the outline of the old continent with tolerable accuracy, and thus obtain some intelligible, and at the same time trustworthy, explanation of the peculiar geographical distribution of the fauna and flora of the West India Islands. As is well known, Cuba, the Bahamas, Hayti, and Porto Rico, instead of showing, as we might naturally assume from their present proximity to Florida, a decided affinity in their fauna and flora with those of the Southern United States, show, on the contrary, unmistakable association with those of Mexico, Honduras, and Central America; the Caribbean Islands show in part the same relationship, though the affinity to the Venezuelan and Brazilian fauna and flora is much more marked.

In attempting to reconstruct, from the soundings, the state of things existing in a former period, we are at once struck by the fact that the Virgin Islands are the outcropping of an extensive bank. The greatest depth between these islands is less than forty fathoms, this same depth being found on the bank to the east of Porto Rico, the 100-fathom line forming in fact the outline of a large island, which would include the whole of the Virgin Islands, the whole of Porto Rico, and extend some way into the Mona Passage. The 100-fathom line similarly forms a large plateau, uniting Anguilla, St. Martin, and St. Bartholomew. It also unites Barbuda and Antigua, forms the Saba Bank, unites St. Eustatius, St. Christopher, Nevis, and Redonda. It forms an elongated plateau, extending from Bequia to the south-west of Grenada, and runs more or less parallel to the South American coast from the Margarita Islands, leaving a comparatively narrow channel between it and the 100-fathom line south of Grenada, so as to enclose Trinidad and Tobago within its limits, and runs off to the south-east in a direction also about parallel to the shore-line. At the western end of the Caribbean Sea the 100-fathom line forms a gigantic bank off the Mosquito coast, extending over one-third the distance from the mainland to the island of Jamaica. The Rosalind and Pedro Banks, formed by the same line, and a few other smaller banks, denote

the position of more or less important islands which must have once existed between the Mosquito coast and Jamaica. On examining the 500-fathom line, we thus find that Jamaica is only the northern spit of a gigantic promontory, which once extended towards Hayti from the mainland, reaching from Costa Rica to the northern part of the Mosquito coast, and leaving but a comparatively narrow passage between it and the 500-fathom line encircling Hayti, Porto Rico, and the Virgin Islands, in one gigantic island. The passage between Cuba and Jamaica has a depth of 3,000 fathoms, and that between Hayti and Cuba is not less than 873 fathoms, the latter being probably an arm of the Atlantic. The 500-fathom line connects, as a gigantic island, the banks uniting Anguilla to St. Bartholomew, Saba Bank, the one connecting St. Eustatius to Nevis, Barbuda to Antigua, and from thence extends south so as to include Guadeloupe, Marie Galante, and Dominica. This 500-fathom line thus forms one gigantic island of the northern islands, extending from Saba Bank to Santa Cruz, and leaving but a narrow channel between it and the eastern end of the 500-fathom line running round Santa Cruz. As Santa Cruz is separated from St. Thomas by a channel of 40 miles, with a maximum depth of over 2,400 fathoms, this plainly shows its connection with the northern islands of the Caribbean group rather than with St. Thomas, as is also well shown by the geographical relations of its mollusca. The 500-fathom line again unites, in one gigantic spit, extending northerly from the mouth of the Orinoco, all the islands to the south of Martinique, leaving Barbadoes to the east, and a narrow passage between Martinique and the islands of Dominica and St. Lucia. At the time of this connection, therefore, the Caribbean Sea was connected with the Atlantic only by a narrow passage of a few miles in width between St. Lucia and Martinique, and one somewhat wider and slightly deeper between Martinique and Dominica, another between Sombrero and the Virgin Islands, and a comparatively narrow passage between Jamaica and Hayti. The Caribbean Sea, therefore, must have been a gulf of the Pacific, or have been connected with it through wide passages, of which we find the traces in the Tertiary and Cretaceous deposits of the Isthmus of Darien, of Panama, and of Nicaragua. Central America and northern South America at that time must have been a series of large islands with passages between them from the Pacific into the Caribbean. It is further interesting to speculate what must have become of the great equatorial current produced by the north-east trades. The water banking up against the two large islands then forming the Caribbean Islands must, of course, have been deflected north, have swept round the northern shores of the Virgin Islands, Porto Rico, and Hayti, and poured into the western basin

of the Caribbean Sea, through the passage between Hayti and Cuba. This water being forced into a sort of funnel, by the 500-fathom line forming the southern line of the Great Bahama Island, which connected nearly the whole of the Bahamas with Cuba, and formed a barrier to the western flow of the equatorial current; this must, therefore, for the greater part, have been deflected north, and either swept in a north-easterly direction, as the Gulf Stream now does, or round the north end of the Bahamas, across Florida, which did not then exist, across the Gulf of Mexico, and into the Pacific over the Isthmus of Tehuantepec. To Commander Bartlett's interest in this subject I am indebted for the first information respecting the lines run between the islands:

Extract from Letter of Commander J. R. Bartlett, U.S.N.

"I connected the islands by running traverses across the ridges. From St. Vincent to St. Lucia the ridge was only from 150 to 170 fathoms below the surface, with a channel of 400 fathoms near St. Vincent. The channel between St. Lucia and Martinique had 500 fathoms in mid-channel, sloping upward to each island. The channel between Martinique and Dominica was a tough one, and I thought I should never find a ridge. The soundings increased regularly on a ridge to 300 fathoms in mid-channel, where I got a sounding 883 fathoms, and then 1,000 fathoms; beyond this the ridge was some ten miles to the westward, with an average depth of 400 fathoms, but I found two peaks with only 40 fathoms. The deep water from the Caribbean Sea makes in between Guadeloupe and Montserrat, but I found a ridge of about 300 fathoms connecting Antigua with Guadeloupe. In this channel I also found a peak with only 40 fathoms. I finished up the line connecting Saba Bank with St. Croix. I found the connection perfect, but the ridge has 700 fathoms water on it near St. Croix. There is 1,000 fathoms three miles north, and 1,800 fathoms five miles south of the ridge. I ran a line from Dog Island to White House Shoal, and back to Sombrero. Here I found a channel about ten miles wide with 1,100 fathoms. The temperature was 38° at 1,100; outside 37½° at 1,600; and 36½° at 2,500. I shall run a number of lines from St. Thomas to Sombrero, to be sure that this channel connects with the deep water off St. Thomas. I ran a line of soundings from the south end of Dominica to Avis Island. The soundings were regular at 1,000 fathoms, to within ten miles of Avis Island."

The soundings made by Commander Bartlett, after I left the *Blake*, to determine the ridges uniting the various islands be-

tween Sombrero and Trinidad, show plainly that the cold water of the Caribbean can only come in through the passage between Sombrero and the Virgin Islands, which is about 1,100 fathoms, with a bottom temperature of 38°, while the 500-fathom line, as I have said, forms a gigantic island of all the islands to the south of Sombrero, including Dominica, with a narrow passage of 1,000 fathoms between it and Martinique; the 500-fathom line again uniting into a large spit, as a part of South America, all the islands to the south of it. Thus the bulk of the water forced into the Caribbean Sea has a comparatively high temperature—an average, probably, of the temperature of the 300-fathom line. The cold water of the Atlantic is, however, again forced into the western basin of the Caribbean through the windward passage, and all this through the Yucatan Channel, between Cape San Antonio and the Yucatan Bank. It is, therefore, incredible that with this huge mass of water pouring into the Gulf of Mexico, there should be anything like a cold current forcing its way up-hill into the Straits of Florida, as has been asserted on theoretical grounds. The channel at Gun Key can only discharge the surplus by having a great velocity.

Mr. Garman, who as usual accompanied me, remained in the West Indies after we left the *Blake* at Barbadoes, for the purpose of making collections of reptiles and fishes, with a view of throwing additional light on the former connections of the islands, as I have here attempted to trace it. One of the most interesting of the reptiles we collected is a gigantic land tortoise, found at Porto Rico, differing only in size from the land turtle still found in Trinidad and adjoining parts of South America. It is closely allied to the gigantic turtles of the Gallopagos, and to the fossil land turtles, of which fragments have been described by the late Professor Wyman. These were collected by Mr. A. Julien at Sombrero, in the phosphate beds of the island.

THE GEYSERS, HOT SPRINGS, AND TERRACES OF NEW ZEALAND.

By JOSIAH MARTIN.

[PLATE IX.]

THE islands of New Zealand have been justly celebrated for their remarkable and beautiful scenery ever since the explorations of the illustrious Captain Cook opened up for our nation a second Britain among the waters of the great Southern Seas.

The Alpine ranges, glaciers, fiords, and sounds of the South Island, and the volcanic formations of hot lakes, geysers, boiling springs, active and extinct craters, with the marvellous sinter terraces of the North Island, have excited the wonder and admiration of travellers of every class. The geologist, botanist, and artist have alike been enchanted with the native grandeur and picturesque beauty of our mountains, forests, lakes, and seas.

The line of active volcanic action (see fig. 1) runs in a N.E. direction from the great active crater of Tongariro (which is situated near the centre of the North Island 6,500 feet above the level of the sea), embracing a belt of country about twenty miles on the N.W., to the insular crater of White Island in the Bay of Plenty, a distance of about 150 miles.

In this area is included lake Taupo, and the hot lake districts of Rotorua and Rotomahana; with geysers, sinter terraces, solfataras, fumaroles, mud volcanoes, hot springs and alum caves, in such profusion and of such magnificent proportions and combinations, as to present scenes unsurpassed in any other part of the world.

Tongariro and the district immediately surrounding it are exceedingly difficult of access, the native owners of the property being very jealous of excursionists, in whom they see only political agents, suspected by them of designs upon their territory. But an enterprising artist has lately succeeded in reaching the mountain, and making the ascent; but not without great exertion, and many vexatious hindrances.

FIG. 1.—SKETCH MAP OF THE ACTIVE VOLCANIC AREA, NORTH ISLAND, NEW ZEALAND.

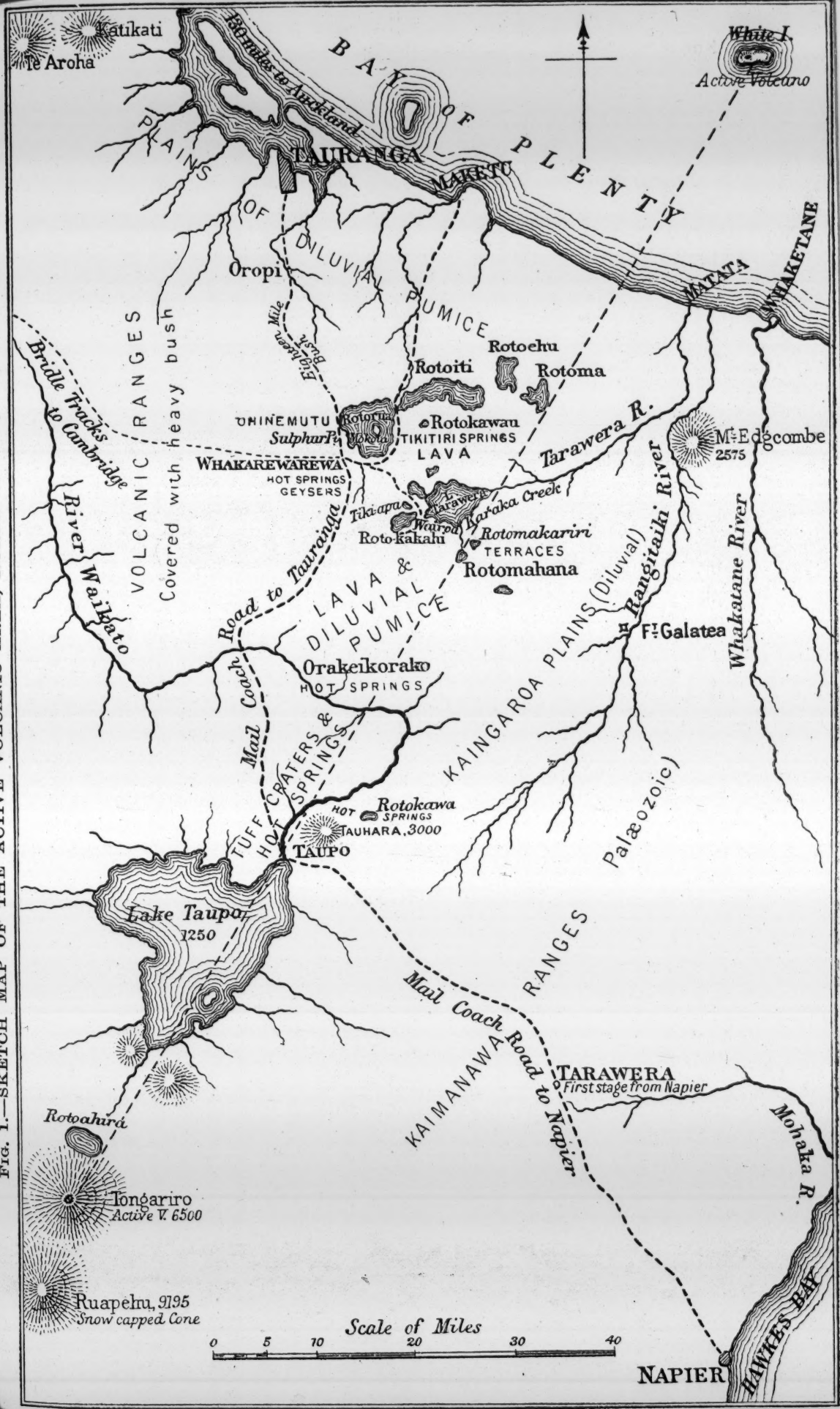


FIG. 1.—SKETCH MAP OF THE ACTIVE VOLCANIC AREA, NORTH ISLAND, NEW ZEALAND.

Taupo District.

Lake Taupo is now upon the main road between Auckland, Wellington, Napier, and Tauranga, and is very easily reached by coach. It has also good accommodation for tourists and travellers, so that this district, and the whole of the country described in this paper, can be visited with comfort, and with no more than the usual difficulties of getting across country roads. Coaches run between the principal towns, and light buggies and saddle horses can be easily procured at Taupo, Tauranga, and Ohinemutu.

Approaching Taupo from Napier, the road passes through lovely forest scenery of hill, valley and gorge, where the man of science and the artist can each find inducements to linger, and to wish for an extension of time in order to "do" the district thoroughly. But we pass on, and as we surmount the last hill and emerge from the bush, a glorious panorama opens before us. Peaks, craters, and basaltic rocks stand out in bold relief above the timber-clothed hill-sides, and seem to strew the valley of Tarawera where the first evening from Napier is spent.

The first view of Lake Taupo is very striking. The wide expanse of water stretches away in the distance, and is lost among mountain shadows, behind which rise the lofty cones of Tongariro and Ruapehu—the former smoking or pouring forth its lava streams, and the latter lifting its snowy peak in silence to a height of 9,200 feet.

As we approach the lake the small clouds seen around its borders, become distinct as columns of steam, and countless hot springs bear evidence to the energy of the volcanic forces which are apparently extinct in the numerous tuff craters around.

The comfortable hotel, stabling, stores, &c., which, with a few other buildings, constitute the *Taupo* township, is prettily situated, but the plains on every side are very barren. The Government have here secured a strip of active springs and bathing pools, but with this exception all this part of the country is in the hands of the Maories. Some shelter has also been provided here for visitors to enjoy the baths without undue exposure to the sun or wind. The ground around is seething with bubbling and boiling springs, and with fumaroles and solfataras of all sizes and at all temperatures; from tiny cups of creamy liquid, to vast cauldrons in trachytic rock, incrusted with glistening crystalline sulphurous deposits; or with siliceous sinter, more or less tinted with ferric oxide.

In this neighbourhood there is a very remarkable geyser cone, which, covering an area of nearly twenty feet in diameter, rises to about six or seven feet; the crater is an oval of six feet mean

diameter, and the basin appears about half-full of bubbling water, about 200° F.; it is built up—like a huge crow's nest—of sticks which are incrusted and cemented with silica; it occasionally breaks out and ejects large volumes of steam, or showers of boiling water. Many ingenious theories have been propounded to account for its singular appearance, but close and continued observation will be required before a satisfactory explanation can be given.

Roto Kawa is a small acid lake in this district, which is approached with extreme caution because of the treacherous nature of the deposits of tufa, obsidian, and pumice, which are broken through by so many hissing jets that, as the soil reverberates to our tread, and the guide repeats his warnings, we confess to a feeling of insecurity, painfully enforced by various reports of unwary wanderers who have fallen through. The ground is insufferably hot to the touch, and here and there we discover yawning chasms of black seething mud from which the vapours of sulphuretted hydrogen, mingled with fumes of sulphurous acid, greatly offend our senses, and painfully remind one of the visionary Gehenna and of its traditional terrors.

Twenty miles from Taupo, and some little distance off from the main road, is the district of Orakei Korako, so ably described by Dr. Hochstetter, where he counted seventy-six jets of steam from one point of observation. The principal geyser of the series is periodically intermittent, throwing up its boiling column about every two hours to a height of from ten to thirty feet; adjoining this is a small sinter basin which forms a luxurious warm sitz-bath—after a few minutes immersion one's skin is covered with a fine deposit of silica of exquisite smoothness. Numerous hot springs on both sides of the Waikato river at this point are highly charged with alum, silica, and carbonate of lime; and these crystallize into forms of great beauty, which are seen to perfection in a deep cavern known as the Alum Cave, in the recesses of which, reflected in the beautiful blue mirror of a pool of warm water, incrustations and stalactites of varied forms and tints delight the beholder.

Recrossing the Waikato we pass through another series of springs and mud pools, with small volcanoes of pink or grey mud; and after a journey of about sixteen miles we cross a hot river which is fed by numerous boiling springs. The luxury of a warm bath *au naturel* can be here enjoyed to perfection; and a spring of delicious cold water will refresh the weary by applications, external and internal. Some of the choicest and rarest of New Zealand ferns are to be found only on the banks of this stream, the humidity of the warm atmosphere being peculiarly favourable to their growth.

Rotorua.

Rotorua is a nearly circular lake of about twenty miles in diameter, surrounded by hills from which the timber has long since disappeared. Near the centre rises Mokoia, a volcanic island, with three conical peaks or craters, and with well-defined terraces which mark a previously higher level of the waters of the lake. Several native wharès or huts, and extensive plantations, are found all round the island, which was in former days a very important fortress, and is still celebrated in Maori legend and tradition. Hinemoa, the maiden, is the heroine of many of their songs and stories. Mr. Domett has immortalized her history in his poem "Ranolph and Amohia;" and Mr. Chevalier had a charming picture of this Maori girl at the Royal Academy.

The seat of active volcanic agency is principally confined to the eastern shores of the lake. A narrow ridge of volcanic clays, rising about thirty feet above the level of the lake, forms the township, where, as at Taupo, the telegraph places us in immediate communication with the business world. On the slope toward the lake is seen the main settlement where the natives spend their time in sensual idleness; the bank of the lake is here perforated with thousands of springs, and these form the cooking places for the tribe; every hut has its boiler worked by nature as close to the door as is deemed convenient; and kits or baskets of potatoes, fish, beef and other edibles are suspended in these pools until ready for table. Over some of the hottest portions of the ground, large slabs of stone are placed, on which, covered by moist grass or weeds, bread is baked; on other slabs, not quite so hot, the lazy recline themselves, and, wrapped or covered with a blanket, enjoy Vulcan's heat on the coldest day.

Several of these springs are celebrated for remarkable cures. Some are reputed to be arsenical, others are sulphurous, and many are impregnated with alkalies. One remarkable pool called by the natives Kuirua (see Analysis No. 3, p. 383), which is fed by numerous hot springs, is celebrated for its saponaceous properties, and is the laundry for the township and settlement. Its temperature varies between 130° and 160° F.; it has a strong alkaline reaction, and clothes are washed here without any artificial admixture of soap or soda.

The natives, who are said to be afflicted with chronic impecuniosity, persistently importune the visitors for gratuities, but under the charge of one of the European residents the tourist is relieved from their presence, and can inspect the exterior of their dwellings without the levy of black mail. The borders of the lake are perforated with numerous springs, and bathing at any

temperature can be enjoyed, and is freely indulged in by natives of both sexes, heedless of the restrictions imposed by the proprieties of fashionable watering places. The little tongue of land on which this settlement stands is quite undermined, and the place is shown where a similar "Kianga," or village, disappeared one night beneath the water, taking all the inhabitants without warning into the yet warmer regions below.

On this slope are some vegetable gardens belonging to the British residents, where fruits, flowers, and all garden products are forced upon a natural hot-bed to a perfection unattainable elsewhere. On the other side of this ridge several very large ponds of water, some about 200° F., are to be seen under their cloudy canopy of steam.

About a mile from this point, on the borders of the lake, is a sulphur point, an extensive plateau of sinter incrusted here and there with crystals of sulphur, where some very remarkable medicinal springs abound, in which some wonderful cures have been effected. (See Analysis No. 7.)

Many invalids, who have been attracted by the world-wide renown of their effects, suffer under great disadvantages from the want of a competent resident authority, and the absence of adequate shelter. Numerous pools are shown, one of which is called the Pain Killer (see Analysis No. 6), but they are merely holes in the ground, or small running streams, which must be cleared out by the visitor to allow of his immersion, and perhaps, directly this has been done, a watchful native takes advantage of the opportunity afforded and steps in first.

A mistake may easily be made in the selection; at one place a boiling and a cold spring, each overflowing from small cisterns of sinter, unite their streams in a third or tepid bath; an invalid on one occasion, intending to use the warm bath, stepped inadvertently into the cold one; the shock was unexpected, and in his alarm it was mistaken for the boiling pool; to remedy his supposed error he jumped into the other nearly up to the middle; his scalded limbs immediately discovered his error, which unfortunately proved fatal. The whole surface adjoining this plateau is incrusted with sulphur; and ponds of various sizes, dark mud holes, yawning cracks, miniature geysers, artificial baths, beautiful basins of bubbling sulphur, thousands of little tiny cups and countless jets of noxious vapours combine the attractive and the repulsive in fantastic profusion.

On the opposite side of the lake are the renowned Tikitiri springs. The columns of vapour which arise from these remarkable eruptions are seen from every part of Rotorua. Geysers are so numerous, and deep spluttering mud holes so abundant, that the spectator is appalled. The largest geyser is about 100 feet in diameter, and boils in billows of great fury,

dense fumes of sulphurous acid arise from the troubled waters, and silver ornaments are speedily discoloured by the dense vapours which are exhaled. (See Analysis No. 9.)

Whakarewarewa, about two miles from Rotorua, is a centre of volcanic activity of great interest to the geologist. The natives will provide huts for the accommodation of visitors, and provisions can be easily obtained. The varied phenomena of the entire district can here be seen in miniature, and as the influence of atmospheric pressure upon the various eruptions and geyser displays can be studied at leisure, some very important investigations may be made at this place with very little trouble or fatigue.

The ground around this point is arid, but within the circle of activity, gardens and orchards display a rich luxuriance. A deep chasm, along which rushes a noisy stream, divides the settlement, the banks on either side being noted for some very remarkable fumaroles.

Through the plantations, and passing several native huts, we come upon a large plateau of silica which reverberates beneath our tread. The temperature of its surface is over 100° F., and a large opening in the centre reveals the fact that we are walking upon a crust of unknown strength and thickness over a large basin of boiling water. Approaching as near as our treacherous foothold permits, we are almost overpowered by the heat and steam. The wind clearing the cloud of vapour, we see Parekihuru, a large hole of about 30 feet in diameter, overflowing with boiling water; fringing the profound azure depths we notice, under the crust on which we stand, beautiful irregular coral-like formations. The excessive heat and the insecurity of our position compel a speedy retreat to a firmer and cooler footing.

Numerous smaller springs, supersaturated solutions of silica, form very beautiful incrustations in a short time, and articles dipped into them are speedily covered with a soft and delicate deposit resembling hoar frost, which is too fragile to bear transport.

Close by is another boiling fountain, rippling over beautiful miniature terraces of pure white sinter which appear like petrified cascades, and falling into a small basin the temperature of which is from 96° to 120° F. (see Analysis No. 2). The stream forms a head of water, and it is artificially conducted by a wooden shoot over the edge of a cold pond, where a patient afflicted with spinal rheumatism can stand upon a mat, and permit the hot water to fall upon his head or back, after which he can easily take a plunge into the cold bath at his feet. Several wonderful cures are attributed to this bath, and a hut has been built by the Maories for the use of visitors.

Several mud holes of different degrees of activity and consistency present some beautiful examples of the formation of concentric rings, miniature craters, radial fissures, and annular combinations produced from several centres which will form a very interesting subject for closer investigation. Here are a few intermittent geysers which require to be teased into activity, and sods thrown into them will be ejected with great violence; some small cavities, which apparently are perfectly harmless, suddenly start into activity, and are so uncertain in their action that they are dangerous to approach without a guide. Numerous baths to which fancy names have been given, are used by natives from all parts of the island for rheumatic or cutaneous diseases, and one is used as a cure for syphilis. An alkaline spring called the oil bath (see Analysis No. 4) is much resorted to by both Europeans and natives.

Upon a higher elevation by the side of a hill of decomposed rhyolitic rock we cross another siliceous plateau with several geysers in all stages of activity. Some are furious in their ebullition; the most interesting being the famous Wakiti, a huge sinter cone built up of beautiful white circular terraces diminishing from one hundred feet in diameter at the base to about three feet at the summit. The apex of the cone is about thirty feet above the plateau, and can be easily reached. A small quantity of steam issues from the funnel, which is a narrow opening, and a deep rumbling can be heard from beneath; but occasionally it throws up a column of water to a height of eighty or even a hundred feet. The natives state that in certain seasons this geyser is very active, and all the smaller ones around play in concert. It is influenced, they say, by the direction of the wind, but whether under a high or low atmospheric pressure has not been observed. We may here recommend intending visitors to secure the services of a European guide from Ohinemutu. Mr. Henshaw accompanied our party, and rendered us very material assistance; but on another visit without his protection we were seriously annoyed by the importunities of the residents, and could not gain access to this, the most important centre of Whakarewarewa, as we refused to satisfy the exorbitant demands made upon our exchequer.

Tarawera.

From Ohinemutu we start on saddle horses, or light American buggies, for Tarawera and Rotomahana, and after a ride of twelve miles arrive at the picturesque settlement of Wairoa, where comfortable accommodation can now be obtained at very reasonable charges. The road has recently been opened and

widened; the ascent from Rotorua passes through several cuttings, made in the decomposed trachyte and diluvial pumice, which, with deposits of obsidian, form the surface of the entire volcanic area. The retrospect over the lake, with its numerous steam clouds, is very fine; but the road through Tikitapu bush will at once attract the attention of every lover of the picturesque; the botanist and entomologist would rejoice to spend days or even weeks in this lovely grove; and when the blue waters of the lake are discerned through the overhanging foliage an expression of delight escapes from every beholder.

Encircled by steep hills, and clothed with luxuriant foliage to the water's edge, this enchanting and at one time inaccessible lake, perfectly reflecting from its azure surface and transparent depth the dense vegetation of its borders, forms a picture of which we have never seen the equal in the Old World or the New. With no visible outlet, the cold blue water of unknown depth always maintains about the same level, and as our "buggy" rolls along the cutting of pumice on its border, we regret that we cannot linger to enjoy its fairy beauty. Ascending, we cross a narrow ridge and look down over another lake—Rotokakahi—at a much lower level, of pale green water, from which, by a subterranean outlet and by a succession of pretty cascades, it reaches Wairoa and falls into Lake Tarawera. Following this stream we arrive at a comfortable hostelry; and at a spot once famous for its miserable accommodation we find a well-furnished hotel.

The natives have now several commodious whale boats (for there stretches eight or ten miles of lake between us and Rotomahana), which replace the old canoes that were so formidable to travellers unused to this mode of transit. Fixed charges are now made by the Maories, but a tribute of £5 is exacted from every photographer or artist who may wish to carry away anything more than mental impressions of the scenery; and the removal of specimens is also prohibited, and with good reason. A fine opportunity is afforded for the contemplation of human nature as exemplified in the aborigines, who are very intelligent, and are more industrious than at Rotorua. Their propensities to appropriation are strong; and they have also a marked appreciation of beer or spirits.

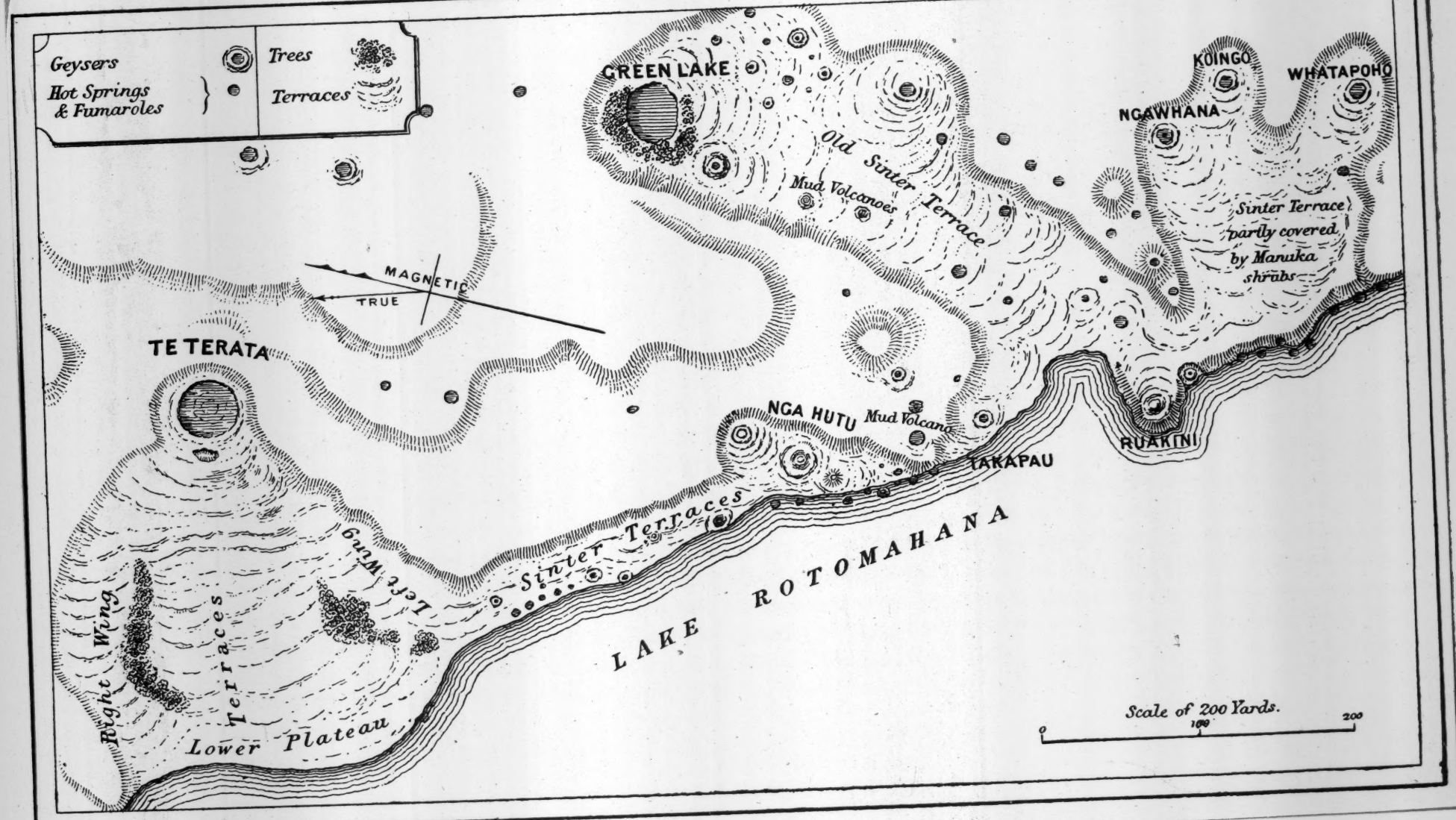
The row or sail along this lake is very delightful. It is 1,075 feet above the sea level, and is surrounded by volcanic hills, the largest, Tarawera, rising about 1,000 feet.

Rotomahana.

Our boat lands us at the mouth of the Kaiwaka creek, where, after paying half-a-crown per head for admission fee and five

FIG. 2.—SKETCH MAP OF THE SINTER TERRACES, GEYSERS, FUMAROLES, AND HOT SPRINGS ON THE EASTERN SHORE OF LAKE ROTOMAHANA.

FIG. 2.—SKETCH MAP OF THE SINTER TERRACES, GEYSERS, FUMAROLES, AND HOT SPRINGS ON THE EASTERN SHORE OF LAKE ROTOMAHANA.



or ten shillings for hire of a canoe on Rotomahana, we make our way past several hot springs and steam jets, and from the top of a small hill catch sight of the dull green water of Rotomahana, fringed with sedges and rushes, and surrounded by barren hills of no great elevation. The terraces and geysers which have made this lake one of the wonders of the world are only indicated by columns of steam, which are rising on every side.

We descend and pass through patches of manuka, or Ti tree scrub, and then standing upon the dazzling white platforms of Te Terata, we are silenced by the resplendent beauty of the scene which bursts upon us (see fig. 2 and Pl. IX. fig. 2).

Sensations and emotions unknown in our previous experience completely overpower us, so that we are unable to describe our impressions in ordinary language, or even to recall them to our memory with vivid distinctness. This wonderful structure has been formed by a geyser of the greatest force and volume, which, bursting forth from the base of a hill of volcanic clays and decomposed lava, has gradually elevated and enlarged its beautiful basins, and, building up terraces and buttresses of unparalleled natural beauty and design by its own siliceous deposit, has retired further and further into the side of the hill, which now overhangs the reservoir with a circular wall, almost perpendicular. As we ascend the delicate stairway, we are almost dazzled by the sublime effect produced upon our senses. We found the use of neutral tint or blue spectacles a great advantage to tone down the absolutely overpowering splendour of the scene.

Every tier reached in our upward progress reveals new combinations and effects. The grand design of the whole is the same everywhere; but the detail is essentially distinct in every part.

As we reach the culminating ridge of the terrace, and review these magnificent gradations spread out fan-like before us, we begin slowly to appreciate their beauties and to understand something of their structure. We count forty distinct platforms or terraces of varied form, but similar character, with numerous basins, resembling the purest alabaster, all filled to overflowing with sapphire, turquoise, or azure waters which trickle over and incrust the edges of their reservoirs and drape them with festoons of sinter.

So very numerous and varied are these baths and fountains, platforms and steps, that we should delight to spend weeks in their neighbourhood, and devote each day to the discovery of some new manifestation of nature's architecture, decoration, and design.

The hill itself seems crumbled and undermined by active volcanic agency, and presents a most interesting field for the student of vulcanology. Several old craters may be traced in

the contour of the hill, and the countless fumaroles, solfataras, and geysers bear witness to the enormous activity at work beneath. The surface is everywhere warm to the touch, and its foothold is treacherous in the extreme; and further evidence of activity may be obtained by a tour of inspection over the ridge, where a puff of steam rises from the soil as it crumbles beneath our tread, and very thick soles are necessary to protect our feet. The hill from which this geyser rises covers an area of about 1,000 yards by 500. It slopes on the S.W. into Rotomahana, or the Warm Lake, and on the N.E. into Rotomakariri —the Cold Lake.

The great basin of Terata is situated at a height of nearly eighty feet above the level of the lake, and 300 yards from the outer edge of the lowest terrace (fig. 2). The reservoir is nearly circular, of about ninety feet diameter, and of a depth variously estimated at from twenty to forty feet. It is nearly surrounded on its inner side by a lip or edge, about six feet wide. Through the dense overhanging steam, the deep azure water of the cauldron may be seen (see Analysis No. 1). It is always hissing and boiling, and possesses a temperature varying from 210° to 214° F., according to its activity. It is so quiet at times that a daring adventurer can walk around its lip, or even descend a few feet into its nearly empty basin; but it will suddenly, and with terrific violence, break into activity, and, throwing up an enormous column of water, fill its basin to overflowing, and perhaps forcibly eject the whole contents in one convulsive eruption, throwing the water to a height of forty or fifty feet, to the certain destruction of any one who has dared to come within reach of its scalding fountain.

Two-thirds of the basin is enclosed by the hill-side, and an island of harder rock stands midway in the opening. This affords shelter for the spectator, as well as an elevated position from which to observe the eruptions or to view the terrace.

The siliceous deposit which forms the terrace extends from the lip or edge of the basin over a large plateau, and then descending in three sections, forms a lower plateau, which has a frontage to the lake of about 200 yards.

The upper plateau receives the very newest deposits, and resembles a small field of ice covered with a few inches of snow. The spectator feels that it is almost sacrilege to tread upon and crush this beautiful crystallized frost-work. The sun's rays, decomposed by these delicate crystals, with sparkling iridescence glisten in fairy splendour. Below the beautiful curves forming the edge of this plateau, and sloping outwards, are rounded masses of snow-like sinter; below these again are several pools of hot water of the richest cobalt hue, or sparkling like sapphire, which, reflecting the overhanging festoons, light them with deli-

cate azure tints; and then another plateau is reached, formed of rippled layers of hardened silica, frosted with recent incrustations.

The formation here divides into three sections: the centre or terrace proper, and the right and left wings; and before reaching the lake these sections are separated by clumps of foliage growing upon the natural soil, but are re-united in the lower plateau.

(*a.*) The central section is the oldest formation, and is built up of (1) huge overhanging buttresses, tattooed or carved into delicate lines, and festooned with incrusted pendent points, from which the water occasionally drips. (2) Terraces, rising tier above tier, of various thickness, but all perfectly level, the edges and faces of each step being rippled or chiselled into lines like the shadows on a woodcut, several grades together appearing like a petrified cascade.

(3) Basins. Near the upper plateau are several basins whose overhanging lips drop the slowly cooling liquid into other basins below. Evaporation is slowly silting up the basins; but at the same time raising and thickening the outer rim. Where some accident has broken through the brim, the increased flow at this point builds up smaller steps of similar form, and at last the broken part is cemented to its original level.

(4) Cups. On the lower terrace tiers, thousands of small cups are formed, all bearing the same characteristic sculpture which gives the name of Te Terata, or the tattooed rocks.

The evident tendency of the whole deposit is to form (5) slopes, which are seen in various stages of transition from the terraced stairway to the even slope which follows the medial line of obliquity. These slopes are very beautiful, as in them can be seen the gradual filling up of buttresses, terraces, and basins, and the ultimate reduction of the whole at some distant date. Some of these slopes are more rounded and steeper than others, but all present the same rough surface; and a passing shadow, or the rays of the setting sun, illuminate these prominences with pleasing effect.

In the central section, and immediately above the lowest plateau, are several tiers of cold-water basins, low and shallow, but discoloured and mottled by confervoid growth. The water in these basins is of a greener tint, and contains a perceptible amount of lower vegetal life. The middle of this central division is broken by an irregular deposit of a different character, apparently caused by some obstruction—a prominence bearing a fancied resemblance to a "boar's head" is formed, and the terrace steps are rounded and broken.

(*b.*) The right wing is an irregular slope broken into steps in several parts of the descent, and containing a large quantity

of sticks, stones, and clumps of soil projecting above the sinter, but all are incrusted more or less with silica. No regular basins are seen in this section, but, where an obstruction occurs, small terraced ridges are formed.

(*c.*) The left wing (looking downward) has similar characteristics; and as the stream, after depositing the silica (held in solution by great subterranean pressure) on the upper or snowy plateau, makes its way over the slope of the hill and among shrubs and grasses, the new deposit, caused by the slow evaporation, spreads its snowy mantle over the soil; the scarcely concealed foliage and mosses sparkle and glisten, but, if gathered, their frosted incrustation speedily falls off. Where the siliceous deposit is indurated and hardened, their forms or outlines may be traced long after the vegetation has disappeared, but we were unable to discover any true petrifactions. The most recent overflow finds its way over this wing, but the tendency is to form incrusted ridges and slopes, and not cups, basins, or terraces. The evidence is strongly in favour of the theory which supposes the central reservoir to have been originally at a lower level and nearer to the edge of the lake, the deposit of sinter having elevated the reservoir and causing it to retreat along the path of least resistance into the side of the hill.

The lower platform is the most extensive, and may be estimated at about one hundred and fifty feet in width, while it has a frontage of about three hundred yards along the edge of the lake. Its surface is in rippled layers, discoloured in many places, and supporting patches of scrub, fern, or moss upon a thin stratum of soil of recent deposit. Its general appearance is that of a pavement of concrete which has been subjected to the action of water overflowing from the lake. From our hasty review we could gain no idea of the thickness of the deposit in any place, but some enterprising geologist will doubtless spend a long vacation in this region and give the world the benefit of his investigations.

Leaving Terata, and passing again through ti-tree scrub, we examine more closely the southern portion of this remarkable volcanic hill. The smaller fumaroles escaping notice, our attention is arrested by two immense geysers (see fig. 2), Nga Hutu, which occasionally works great wonders, and Kakarike, which is truly appalling, its huge cauldron (about 50 feet in diameter) rolling in boiling waves, which break against its side and dash upward in angry menace. Passing several hot springs on right and left, a terrific roar breaks forth from a deep recess at some distance, caused by an escape of steam in great volume at enormous pressure. Subterranean rumblings and noxious exhalations combine to form a sensation the most perfect antithesis to

our experiences on Terata. Tophet must have been a paradise to this spot; and if Dante could have visited Rotomahana, what fearful horrors would have been suggested to his vivid imagination.

Across a platform of hot stones and the remains of an old sinter terrace broken up by the shifting soil, we find a geyser, once furiously active, now nearly extinct, and so quiet that it is used as a favourite cooking place by the natives, who dare not venture too close to the more terrible of the group.

In a deep hollow of forbidding aspect are several mud holes ejecting an edible acidulated mud. We declined a meal upon such dainty fare, but one hole was suggestive of a giant's porridge pot. The rising of bubbles, the annular eruptions, and the effects of volcanic discharges in plastic clay forming ridges and rings, would be interesting to a student of selenography. From hasty observation we failed to trace any distinct resemblance to lunar craters.

The green lake, a pool of pea-green water, is a striking contrast to the prevailing character of the scenery. The water is deep and cold, slightly acidulated; but we are not aware of any analysis to account for its remarkably verdant colour. The border of the pool shades into blue, and its level is reported to be unaltered.

There used to be a small steam-whistle, but some inquiring tourist, emulating the famous juvenile experiment upon the domestic bellows, inserted his walking-stick into the narrow vent and effectually stopped its music.

There are several wharès or native huts on this point and on two small islands in the lake, but they have been long since deserted except by rats and fleas; the ground is so honeycombed with boiling springs that it must be very dangerous for occupancy. In one of these deserted huts we found luncheon prepared; our potatoes and kaura (small cray fish) had been cooked in one of the natural kettles, and we found that Bass's pale ale was not to be despised, although at a cost of 2*s*. 6*d*. per bottle and a porterage of many miles.

Otakapuarangi—the Pink Terrace (Pl. IX. fig. 1).

A native canoe ferries the visitor across the lake to the foot of the Pink Terrace, which is seen rising in fairy beauty, tinted as with rosy sunset hues, and like its paler sister broken into about fifty distinct terraces and cascades of varied height and form. Enclosed in a horse-shoe curve of the hill this formation becomes much narrower at its embouchure on the lake.

Ascending the steps, the observer is struck with many points of resemblance to Terata, and also with essential points of difference.

1. The surrounding hill is of harder and firmer rock, and but few other springs are seen, and these are confined to the base of the hill. The summit is gained with ease and safety, and a magnificent and unequalled panorama of the whole is seen; it expands to greatest width in mid-descent, and narrowing at its fringe. The deep blue of the reservoir and basins form a very pleasing contrast to the fresh pink of the upper and newest formation. This colour is lost nearer to the lake, and the lowest lines resemble those of Terata.

2. The geyser is a little smaller than Terata and is more open; its deep azure water, although constantly boiling and steaming, overflows quietly and, covering a pavement like alabaster, falls over (3) the upper plateaux, on which are inscribed the names of tourists and the dates of their visit. These slabs are perfectly smooth, and inscriptions in pencil become indelible under a coating of silica in a short time; but upon examining dates of twenty or thirty years since, the deposit or film was so thin as to be scarcely perceptible except as a thin glaze. (See Analysis No. 5.)

4. The basins. There are five basins used for bathing pools, and presenting the most luxurious bath that can be imagined. The temperature is graded as the baths, and the inner surface has a soft feeling like satin or velvet.

5. The overflow here divides; finding a new channel to the right, it leaves the old formation and carves out for itself a new course which it covers and decorates with its peculiar deposit. The old formation resembles Terata in its overhanging buttresses, its engraved or tattooed festoons, and its stalactite fringes.

6. The new formation is a cascade of unmatched beauty; the stream leaps from rock to rock, forming rounded masses and slopes of pink sinter, but no distinct terraces are seen until the new stream flows once more over the older at an elevation a little above the lake.

The evidence of these distinctive features seems to indicate a period when the Pink Terrace was, like Terata, discharging under high pressure; and comparing the two terraces it is evident that the frosted incrustations and snow-like deposit upon the upper platform of Terata, are due to the sudden deposit of sinter hitherto held in suspension by enormous pressure. The smoothness of the floor of the Pink Terrace, and its marble inscription slabs, is caused by the slow evaporation of the water in its constant overflow. A trace of oxide of iron in the analysis of the water and of the sinter sufficiently indicates the source of its prevailing tint.

Under certain conditions of wind or weather, this geyser is said to cool down and its outflow to cease, but systematic investigation is needed to decide the conditions of such irregularity.

Immediately to the left of the Pink Terrace is a large solfatara, presenting in opposite extreme the most extraordinary features. Literally a lake burning with fire and brimstone, it is awfully suggestive of Tartarus, and although its repulsive character is attractive we must not linger in our description.

On the western shore of Rotomahana there are five or six other basins of boiling water of lesser magnitude. The waters of the lake vary in temperature, but it is saline in all parts except the north-west corner, and here as our canoe is pushed in among the sedges the Maori boy dips up a supply of cool fresh water, sparkling and clear.

The return journey by canoe takes us through the narrow rapids of the Karaka creek, where hissing steam-jets and mud holes line the banks. At Tarawera we re-embark, and stimulating our Maori boatmen with *promises* of good cheer when we reach the hotel, we make rapid progress to Wairoa. The return journey will be made *viâ* Ohinemutu, and through the "eighteen miles bush" by good but irregular coach road, forty miles to Tauranga, a beautiful harbour on the Bay of Plenty.

ANALYSIS OF MINERAL WATERS.

By Prof. W. Skey, Analyst to the Geological Survey of New Zealand.

(*From the "Transactions of N. Z. Institute,"* 1877.)

1. *Te Terata, Great Geyser of Rotomahana.*

	Grains per Gallon.
Silicate of soda	68·48
Monosilicate of lime	1·62
„ „ magnesia	·53
„ „ iron	·51
Sulphate of soda	7·84
Chloride of potassium	2·87
„ „ sodium	62·61
Phosphate of alumina	traces
Lithia	„
	144·46

All but soda are monosilicates; the little excess of silica, 7·66, is included in the soda silicate.

2. *Medicinal Springs at Whakarewarewa.*

Silicate of soda	16·32
„ „ lime	1·61
„ „ magnesia	1·14
„ „ iron	·39
Sulphate of soda	13·47
Chloride of potassium	1·24
„ „ sodium	53·61
Phosphate of alumina	traces
	87·78

3. *Kuirua, or Saponaceous Spring, Ohinemutu.*

Monosilicate of soda	2·57
„ „ lime	·34
„ „ magnesia	·12
„ „ iron	·31
Sulphate of soda	10·31
Chloride of potassium	2·08
„ „ sodium	45·70
Phosphate of alumina	traces
Silica, free	18·42
	79·85

4. *Caustic or Oil Bath, Koroteoteo, Whakarewarewa.*

Monosilicate of soda	2·08
„ „ lime	3·16
„ „ magnesia	·76
„ „ iron	·85
Sulphate of soda	7·49
Chloride of potassium	1·46
„ „ sodium	66·34
Silica, free	22·40
	104·54

Water distinctly alkaline or slightly caustic.

5. *Pink Terrace, Rotomahana.*

Silicate of lime	1·91
„ „ magnesia	1·16
Chloride of potassium	1·05
„ „ sodium	93·55
Sulphate of lime	10·96
„ „ soda	1·01
Alumina phosphate	·54
Silica, free	43·95
Iron oxides	traces
	154·13

Temp. 204° to 208° F.

6. *Sulphur Bath, Ohinemutu, "The Pain-killer."*

Sulphate of potash	2·96
„ „ soda	34·37
Chloride of sodium	59·16
„ „ calcium	3·33
„ „ magnesium	1·27
„ „ iron	·25
Phosphate of alumina	traces
Silica	16·09
Hydrochloric acid	7·60
Sulphuretted hydrogen	2·01
	127·04

(7.) Te Kauwhanga Mud Bath, 1¼ mile from Ohinemutu. Thick brown muddy water, covered with oily slime; temperature 80° to 100° F., depositing a heavy muddy sediment; has persistent acid reaction and an offensive odour.

(8.) Ariku-Kapakapa, 2 miles from Ohinemutu. Small pool; strong outflow; temperature 160° F., depositing sulphur; reported to have powerful curative properties.

(9.) Te Kute, Great Spring of Tikitiri. Temperature 100° to 212° F.; muddy brown, containing a large proportion of sulphuretted hydrogen; reported wonderfully efficacious in rheumatism and cutaneous diseases.

	7.	8.	9.
Sulphate of potash	·77	·38	·59
„ „ soda	23·71	12·51	12·66
„ „ alumina	1·46	·68	11·22
„ „ lime	2·04	2·21	1·01
„ „ magnesia	1·62	1·29	·69
„ „ iron	1·47	3·15	1·73
Phosphate of alumina	traces	traces	traces
Sulphuric acid, free	7·60	13·95	·77
Hydrochloric acid, free	7·66	2·62	1·63
Sulphuretted hydrogen	3·19	—	5·74
Silica	13·86	18·15	12·40
	66·38	54·94	48·44

EXPLANATION OF PLATE IX.

FIG. 1.—Otakapuarangi—General view of the Pink Terraces, Rotomahana—from the Sulphur pool.

FIG. 2.—Te Terata—View of the cold-water basins on the White Terraces, Rotomahana.

(From Photographs by Burton Bros., Dunedin.)

Fig. 1. PINK TERRACES, ROTOMAHANA.

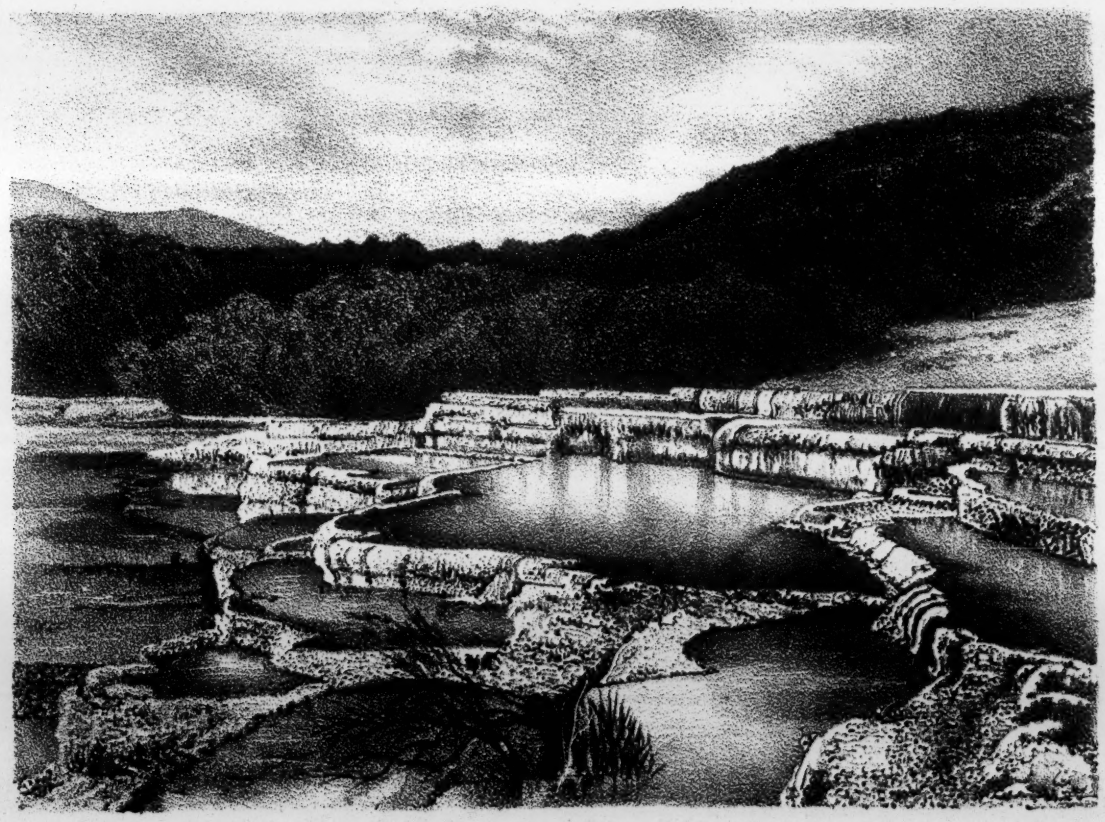


Fig. 2. WHITE TERRACE, ROTOMAHANA.

Mintern Bros lith.

THE MOST POWERFUL TELESCOPE IN EXISTENCE.

By E. NEISON, F.R.A.S.

WHICH is the most powerful telescope in existence? Define the meaning which ought to be attached to the adjective "powerful" in this question. The most powerful telescope in existence is that existing telescope which can do the most work. The work of a telescope may be said to be to enable you to see and to enable you to measure. Therefore, that telescope with which you can see most and can measure best, is that which can do the most work, and is unquestionably the most powerful telescope in existence.

Which is the most powerful telescope in existence?

Everyone has heard of the two giant telescopes which were constructed nearly forty years ago by the late Lord Rosse, and which were erected at his residence at Parsonstown, about fifty miles from Dublin. The first great telescope constructed by Lord Rosse was a reflecting telescope with a speculum three feet in diameter and twenty-six feet in focal length. It was carried in a ponderous tube moving in a massive iron mounting by means of ingenious machinery. When it was finished in the year 1840 it was considered the grandest instrument in existence, and from its employment in the study of the heavens enormous advantages were expected to be gained for astronomy. Scarcely, however, was this telescope out of the hands of its maker, than Lord Rosse resolved to construct a second telescope of still larger dimensions. With enormous skill, patience, and ingenuity Lord Rosse carried out this intention, and by the year 1846 had finished his second grand telescope, the instrument commonly known as "Lord Rosse's Telescope." It has a metal speculum six feet in diameter and fifty-four feet in focal length. This enormous mirror, which weighs nearly four tons, is placed in a great tube eight feet in diameter and fifty feet in length, and this tube is carried by a massive iron mounting supported by two lofty castellated buildings, each nearly sixty feet in height. The weight of the telescope and its mountings is enormous. By

ingenious methods the observer who is using the telescope is placed in a kind of cage, suspended in the air from the mounting of the telescope and carried up and down along with the instrument.

To this day this giant telescope of Lord Rosse's retains its position as the greatest telescope in existence. In its enormous size it has still no rival, in its massiveness and weight it is long likely to retain its preeminence.

Which is the most powerful telescope in existence?

Lord Rosse's giant telescope, of course will be the answer of most people; it will be the answer of the great majority of scientific men; it would be almost the unanimous answer of the British Association, of that Section A which is supposed to keep the world informed of the great achievements of astronomy and of optics.

Is this the true answer?—No.

To most people, to most scientific men, this answer will come like a shock, for to them it has long been a cherished tradition, an article of faith, almost an axiom, that Lord Rosse's giant telescope was the most powerful telescope in existence. To those astronomers who are observers, astronomers not stargazers, it is well known that for years this giant telescope of Lord Rosse's has been beaten in power by far smaller and more compact rivals. In fact, it is doubtful whether in real power it is much superior to its smaller companion, the three-foot telescope.

There are many who judge a telescope by its size alone, who compute its excellence by aid of a two-foot rule and a knowledge of its cost in pounds. With them a telescope with a metallic speculum weighing four tons and measuring six feet in diameter, with a tube fifty feet long, and costing a thousand pounds, ought to give so much light, have such and such separating power, and show this or that object. It is true with small telescopes a great deal may be done in this way, but experienced observers know that the real power of a telescope can only be ascertained by a study of what it has done. Tried by this test, the giant telescope of Lord Rosse breaks down. It has not the accuracy of definition which constitutes the real power of a telescope, for it is mainly upon this that depends its capability for doing work. Compared with the metal specula which were made at the time when Lord Rosse's telescope was constructed, the great speculum of Lord Rosse's instrument might come out with credit. But great improvements have since then been introduced into the manufacture of reflecting telescopes, and the present silver-on-glass reflecting telescopes successfully rival the finest achromatic telescope in definition and in power.

In days gone by repeated reference was made to the wonderful things which could be seen upon the surface of the moon with these two giant telescopes of Lord Rosse's. Picturesque descriptions were given of the minute features which were visible, amazement was often expressed at the small objects which could be seen. Still more interesting accounts were given of what *ought* to be visible,—a carpet of pronounced pattern as big as Lincoln's Inn Fields, the Castle at Dublin, the Courthouse at Cork, a house, or even a man, provided he were big enough. All these *ought* to be seen if they happened to be on the lower surface. Yet when we come to consider what it really is which is described as being seen, when we calmly examine the various drawings which have been made by the aid of one or the other of these great telescopes, then we find that they show nothing which cannot be distinctly seen and drawn by the smallest astronomical telescope of high excellence. An enormous blaze of light is gathered by the telescopes, but all this light reveals nothing which cannot be seen with far greater ease in a far smaller telescope. There are in existence a number of drawings of the planets, and observations of their satellites; there are also observations of close double stars, or faint companions to bright stars, all made with one or the other of these two telescopes. Yet nothing has been seen which is beyond the power of a good astronomical telescope of comparatively moderate aperture. It is only in observing the dull ill-defined nebulæ that Lord Rosse's great telescope has any exceptional advantage, though even in this respect it is probably much overrated. As an astronomical telescope either of Lord Rosse's telescopes would be fairly beaten by either of the fine eighteen-inch reflectors which are now in existence.

If, then, Lord Rosse's great telescope is not the most powerful in existence, what answer is to be given to the question with which we commenced? Which *is* the most powerful telescope in existence? There are the great refractors of Pulkova and of Cambridge, U.S., each of fifteen inches in diameter and 23 feet in focal length. There is the still larger refractor of Chicago with an aperture of eighteen inches and a focal length of 23 feet. All these instruments are of high excellence in defining power, the essential point where Lord Rosse's breaks down. There is the reflector of Mr. Lassells, with its metal speculum of two feet in diameter and its tube twenty feet in length. There is the great Melbourne reflector, with its great metal speculum of forty-eight inches in diameter, the second largest telescope in the world, but by no means so sharp in definition as might be desired, so that it failed to reveal the satellites of Mars which were seen with an instrument of not one-sixth the diameter in Europe.

There is also the great reflector of the Paris Observatory, with a silver-on-glass speculum nearly four feet in diameter, an instrument whose power is seriously injured by the imperfect definition arising from the flexure of its thin speculum. There is also the large refractor constructed for Mr. Newall, of Gateshead, with an object-glass twenty-five inches in diameter mounted in a tube nearly thirty feet in length.

But all these instruments must yield the palm to the great refractor of the United States Naval Observatory at Washington, a splendid instrument, with an object-glass twenty-six inches in clear aperture and 33 feet in focal length. This magnificent instrument is equatorially mounted and driven by clockwork, so that it is complete as an astronomical telescope. The Washington refractor is, however, not merely a telescope of great dimensions; like more than one of those previously mentioned, it is an instrument of high optical excellence. Its definition is crisp and sharp, and it brings every ray of the enormous amount of light which it collects to a sharp focus as a very minute point, so that none is wasted. It was with this fine telescope that Professor Asaph Hall made his famous discovery of the satellites of Mars, that Mr. Burnham discovered a number of the most minute companions to the brighter stars, and that Professors Newcomb, Holden, and Hall have observed and measured the smallest satellites of Saturn, Uranus, and Neptune. It is this magnificent instrument which is supposed by most astronomers to be the most powerful telescope in existence. Then our answer to the question with which we have commenced ought to be—the great refractor of the Washington Observatory. No!

Then which is the most powerful telescope in existence?

The most powerful telescope in existence is the magnificent new reflecting telescope which has been just finished by Mr. A. Ainslie Common, and is erected at his residence at Ealing. This telescope has a silver-on-glass speculum, 37½ inches in diameter, and a focal length of just over twenty feet. It is equatorially mounted in a novel but most efficacious manner, and is driven by a powerful clock controlled in an ingenious manner by a method invented by Mr. Common. This new telescope, which has only been finished about a month, has turned out a great success, and is unquestionably the finest and most powerful telescope which is in existence.

For the last three years Mr. Common has had in his observatory a fine silver-on-glass reflector with an aperture of eighteen inches and a focal length of nearly ten feet. This telescope was mounted by him on an equatorial stand of his own design, on what is known as the "Sissons" principle. For efficiency, power, and excellence this eighteen-inch reflector is as yet without

a rival in England, and was only beaten perhaps by the great refractor of the Washington Observatory. With this instrument was made a number of observations of the faint satellites of Saturn and Uranus, which rendered the Ealing Observatory a familiar name to all astronomers. When, in 1877, the astronomical world was electrified by the announcement of Professor Asaph Hall's discovery of the two satellites of Mars, it was to Ealing that astronomers looked for systematic observations of these faint objects, and it was from Ealing Observatory that came the only systematic series of measures of these objects which has been furnished by England. Astronomers may congratulate themselves, therefore, upon this new telescope being in good hands, and in an observatory where it will not be allowed to rust in idleness like so many of the finest instruments in England.

Satisfied from the performance of his eighteen-inch Newtonian reflector that it would be possible to successfully construct much larger instruments of this kind, it seems to have been about two years ago that Mr. Common first seriously thought of constructing a very large reflecting telescope with a silver-on-glass speculum. It was obvious that this would be a serious undertaking, and one which would require much thought and ingenuity to carry it out successfully. Many difficulties would require to be boldly faced and successfully overcome. The expense alone would have been sufficient to deter most men. Experience, skill, courage, perseverance, money; all would be required if success was to be won.

It was decided to first undertake the manufacture of a telescope with an aperture of $37\frac{1}{2}$ inches and a focal length of about eighteen or twenty feet. This was a much shorter focus than had usually been thought essential for an instrument of this large aperture. Generally instruments of this kind are made with a focal length of from nine to ten times their diameter. This would correspond to about thirty feet focus for a speculum of the given size. The fine performance of his eighteen-inch telescope had convinced Mr. Common that it was not necessary to give a greater focal length than fifteen or sixteen feet. But there were two conflicting interests to be reconciled. The shorter the instrument the easier it would be to mount, and the easier to observe with; but, on the other hand, the longer the focus the better it would be for taking photographs of the heavenly bodies, and this last was one of the main uses that the new telescope was intended for. With the view of best reconciling these two views the instrument was designed with a focus of some twenty feet.

The very first step to be taken was to undertake the manufacture of the glass speculum, and here at the outset an

enormous difficulty presented itself. To make a speculum of the required dimensions it was necessary to have a disc of good crown glass about thirty-eight inches in diameter and from six to nine inches in thickness. Well, purchase such a disc; or rather, as it was not likely that such a thing could be bought ready-made why, order one. This seems feasible enough. But there was not a firm in England who would undertake to make such a thing. In fact, at the time, the opinion was freely expressed that such a thing could not be made. This was a serious obstacle, for nearly all the glass used for optical purposes came from England. Determined not to be baffled, Mr. Common applied to a French firm, and they produced the disc of glass which was essential before a single step could be taken. The first difficulty was faced and overcome.

After mature consideration the grinding and polishing of the speculum into which this glass disc was to be turned was entrusted to Mr. G. Calver, of Widford, a well-known maker of glass specula. From its enormous size, over twice as large and ten times as heavy as any speculum which had ever been manufactured before, it was necessary to construct new and more powerful machinery and even a new building. Nothing daunted, however, Mr. Calver agreed to do his best to turn this great mass of glass into an excellent speculum, though of course he could not guarantee anything, the entire risk necessarily remaining with Mr. Common.

This settled, the greater portion of the task remained to be faced. Given a speculum of the specified size, how was it to be mounted, and how was it to be used. Firstly, the glass speculum must be mounted with such care that, despite its enormous weight, it must nowhere bend by as much as one ten thousandth of an inch. Secondly, the glass speculum and the iron cell which supports it must be fastened at the end of a tube some twenty feet in length, and this tube must be supported by an elaborate mounting by which it can be pointed to any desired part of the heavens, and moved by clockwork so as to follow the apparent motion of the celestial bodies. Thirdly, arrangements must be made so that an observer can always use the telescope, and be enabled to look through the eyepiece of the telescope whatever position it may be in—no slight task, seeing that the said eyepiece must in some positions of the instrument be over twenty feet from the ground. Lastly, the telescope must have an observatory which will shield it from the weather, and yet permit any part of the heavens to be examined with the telescope.

When the instrument has a metallic speculum, like the large reflecting telescopes of Lord Rosse, and Mr. Lassells, and that at Melbourne, it is much easier to satisfy the first condition than

when the speculum is made of glass; for it is possible to cast the speculum with grooves, projections, and recesses in its back, by means of which the task of supporting it is much simplified. With a glass speculum it is not practicable to have these aids, so that the back of the speculum is cast quite flat, and usually rests on a flat plate of metal. By an ingenious method of balanced arms Mr. Common has contrived to support the speculum so that it is perfectly free from flexure. Thus the first point was secured.

The second point, or the method by which the telescope should be mounted, was a problem which required long and serious consideration. Mr. Common devised a new and most ingenious method which, after long consideration, he thought would furnish a means of steadily supporting the telescope. In this steadiness is most essential, the slightest vibration, vibrations absolutely invisible to the eye, would ruin the performance of a telescope. The weight of the moving part of the telescope amounts probably to four or five tons, and this has to be kept in motion by a clock, yet it must not be liable to the least tremor or vibration. The difficulty of the problem is evident. His plan of a mounting was submitted by Mr. Common, for criticism, to several well-known astronomers, who might be supposed competent to advise on this subject. As might have been expected, very diverse opinions were expressed; at most, one seemed to decidedly favour the plan, others seemed doubtful, and more than one were decidedly adverse. The result was to leave that matter much as it stood at first, so that Mr. Common decided to persevere in his original design. The success which has crowned his labours shows that he was correct in his judgment. It would be impossible to describe the method of mounting employed without the aid of several detailed drawings, but reference may be made to one ingenious point. As in all equatorial mountings, nearly the entire weight of the moving part of the telescope (in the present telescope five tons) rests on the bottom pivot of the polar axis. This pivot, therefore, is exposed to enormous friction, and is a common cause of vibration. To obviate this, Mr. Common, by an ingenious arrangement, supports the whole polar axis in mercury, thus taking off nearly the entire friction, and the whole instrument moves as if it were floating. By this means he is enabled to drive the whole telescope by means of an ordinary train of clockwork, regulated by the governor, which he had invented for his smaller telescope.

The last two points specified above are obtained by making the observatory itself the ladder by which you approach the eye end of the telescope, and the whole observatory revolves on iron wheels running on a circular railway. By means of a wheel on

your left, you can raise or lower yourself at pleasure, and observe with the telescope in any position. The whole observatory only requires moving about once in two hours, and can be moved with ease by one hand.

Within a year of its being begun, the telescope was rapidly approaching its completion. The great speculum had been brought to the right shape, and was partially polished, and every day the announcement was expected that it was completed, or at least only required the final finishing touches. Suddenly a telegram arrived—an ominous thing. Was it to announce an imperfect figure? This would be a most annoying thing, for it would require the whole to be reground and repolished. But no, it was very brief, but it announced a terrible misfortune. It was a pressing request to come down at once. *The whole speculum had burst into a thousand pieces.*

It was a terrible blow, for it was the very misfortune which had been prognosticated by the English manufacturers and by the greater number of astronomers, including those who had had much experience in the construction and use of specula. The explosion had been terrific. The whole workshop was covered with jagged, torn masses of glass, varying in weight from ten or twelve pounds to an impalpable dust. Mr. Calver had had a narrow escape, but he and his workmen escaped without serious injury. The monetary loss was great, and bid fair to be greater, for with the loss of the speculum the rest of the telescope became useless. It might well seem that they were right who held the view that large silver-on-glass specula were impracticable, as from the difficulty in annealing large masses of glass they might be expected to break at any moment.

Within an hour or two of receiving the telegram announcing this terrible mishap Mr. Common was in the library of the Royal Astronomical Society. While there he was met by a friend, a fellow astronomer, who, being aware that news was daily expected of the completion of the great speculum, asked him for the latest intelligence. Mr. Common calmly handed him the fateful telegram. He was thunderstruck, for it was so unexpected, and he was one of those who had looked for much gain to astronomy to accrue from the construction and subsequent employment of this grand new instrument. After expressing, no doubt imperfectly enough, his sorrow, sympathy, and disappointment, he naturally put the question—"What can you do now?" The answer came gently enough. "Do? Why, I have telegraphed over to Paris to see if I can't get two more discs of glass. It will be one to spare in case of another explosion."

Success must crown indomitable courage like this. The new discs arrived, and were duly transferred to Mr. Calver. One

was selected, and, after much labour, ground, polished, and finished. The remaining portion of the instrument and the observatory were pushed on as quickly as possible. On August 1, 1879, the instrument was complete, and the grandest and most powerful telescope in existence stood finished before its maker, designer, and owner.

An instrument of this large aperture will take a long time to thoroughly test, but it has stood triumphantly all the tests which have been applied hitherto. It has been tested on the moon, a most crucial test in experienced hands, on Jupiter and Saturn, and on faint companions to bright stars. In all cases satisfactory results have been obtained.* This proves that the telescope must be at least of fine quality, and it bids fair to turn out of the highest excellence. It has been used to take photographs of the moon, with results very satisfactory to those who are experienced in these matters. There can be no doubt, therefore, of its claims to be a success, so that ere long it will take its place in the eyes of most astronomers as the greatest optical instrument in existence, and the credit of having manufactured and of possessing the most powerful telescope in existence has now passed from America back to England.

It may be legitimately asked, What will be the future work of this grand instrument? Will it be used to increase our knowledge of astronomy, or will it be allowed to rest in idleness, like so many other fine instruments? It is to be trusted, and it may be safely anticipated, that the former will be its fate. It will wear out, not rust out. There is much in astronomy which this grand telescope can do. It can be used for observing the faint and difficultly visible satellites of Mars, Saturn, Uranus, and Neptune. All these pressingly want observing and measuring, and there are few telescopes of sufficient power and excellence to do the work wanted. It can be easily done with the new one. Then there is the important question to be settled, Are there other satellites to those planets than those known? To this telescope will fall the task of searching for a third and more distant satellite of Mars, for a fifth satellite to Jupiter, for a ninth and tenth satellite to Saturn, for a fifth and sixth satellite to Uranus, and perchance half a dozen new moons of Neptune. Moreover, there are the extremely interesting problems connected with the minor planets. Does Vesta, Juno, or Pallas, possess a satellite or satellites? If so, their discovery would be a great thing for astronomy. Astronomers suspect that away beyond Neptune there may be still another giant planet, still another member of the solar system. If so, it will

* Lately this telescope has shown the outer satellite of Mars three weeks before it was thought possible it could be seen with the great telescope at Washington.

be very faint, and it will require a powerful telescope to search for and discover it.

There is yet another field in which this new telescope may reap great advantages for astronomy. It is suspected that more than one of the stars, those distant suns, may be attended by opaque dull planets. Mathematical analysis has already pointed to the existence of these attendants. It remains for the telescope to discover them. If the new Ealing reflector be really of the very highest excellence, it will be with that instrument we ought to look for these attending planets, these members of a foreign solar system.

Lastly, there is the great field of photography. The new telescope takes instantaneous photographs of the moon two and a-half inches in diameter, photographs which can be enlarged with ease to good pictures of the moon a foot in diameter, pictures which will be valuable for astronomy, not mere interesting curiosities of science. It will, moreover, take photographs of Venus, Jupiter, Mars, and Saturn, showing much detail, and capable of being enlarged to half an inch in diameter. These planetary photographs will be of great use, as recording in unmistakable characters the true position and aspect of these planets and their satellites at different known epochs.

The foregoing sketch will show that in constructing this new instrument Mr. Common has contributed in a most important degree to the advancement of astronomy.

FLIGHT AND ITS IMITATION.

By FRED. W. BREAREY, Hon. Sec. Aëronautical Society of Great Britain.

THE persistence with which men in all ages, as far as history travels, have pursued the study of flight, proves that there is a better foundation than the mere wish to fly in favour of their aspirations. The hope has outlived the empirical attempts of our progenitors. The same examples of flight are presented to us as to them. We have equally looked upon accomplished facts, viz., the transportation of heavy bodies in a medium so thin that we breathe it.

Some time previously to the Montgolfier discovery, M. Blanchard had made several unsuccessful attempts at flight by means of wings. He hailed with renewed hope the invention of the balloon, by the aid of which he thought that he could attain the buoyancy denied to him by the manipulation of wings alone; not only, however, is buoyancy destructive to mechanical flight, but the magnitude of the means employed to obtain it dwarfed all his apparatus. The effort at flight was imperceptible; and at length he used his wings in beating the air so as to retard descent, which in some cases he no doubt achieved. The balloon remains as an aid to man, not yet sufficiently utilized, although in the sense of aërial navigation its scope is too limited ever to be of commercial utility. The bird in the air, however, still continues to present itself a living witness and fulfilment of a great mechanical problem up to the present time unadapted to man's aërial transit. All the great inventions by which the world has benefited have been worked out in the study, and often in the ill-supplied workshop of the man of science, sometimes for ages before the money-maker deemed them worthy of his attention. And so, during these latter years, the subject of aërial navigation has been approached with the certain knowledge that if its solution lies in the adoption of mechanical means, in compliance with mechanical laws, then the problem must of necessity be solved by the increased, and increasing, knowledge and intellect of man. What, then, is the foundation for the hope that man

will ever be able to navigate the air? First, of course, the fact that creatures possessing weight are endowed not only with perfect adaptation of means, but with the mechanical instinct to put them to use without waste. The students of aëronautics say that they can imitate such means. It is clear, however, that to construct the required apparatus, without the attainment of precise knowledge as to the work which the apparatus is to perform, would be useless labour. Societies have been formed to discuss the mechanical conditions. The Aëronautical Society of Great Britain, of which I have the honour to be honorary secretary, was formed immediately after the subject was introduced by me in a paper read before the British Association at Birmingham in 1865. The papers and discussions, printed in our annual reports, have thrown much light upon the action of a bird's vibrating wing upon the air.

We all know what this thin medium can effect when in motion as what we call wind. Our critics, courteously sometimes, strive to conceal their amusement when we talk to them of one day navigating the air. To them the balloon, being a fact accomplished, presents the only means because of its buoyancy To them the tornado presents no suggestion.

Ships, trees, houses, and towns may be scattered like sand, but to them no idea is presented. I lately read a report of a hurricane in New South Wales in which the speed and force of the air were carefully taken. For a short time the velocity of the wind was stated to be 153 miles per hour, and the pressure no less than 117 lbs. upon a square foot of surface exposed to it.

When speaking to men of science upon the subject of the navigation of the air one often hears the expression: "Yes; I don't doubt that some day or other the question will be solved, but not in our day." This is meant to be an easy and safe way of avoiding the discussion of the subject. The savant smiles, and says, "Good day to you;" and leaves his interlocutor in wonderment that even with his hands well sanded his eel has escaped him. "Not in our day," he repeats, and ponders in wonder as to the true application of the expression by so very learned a man. "Not in our day;" and why not in our day? Has there ever been in the world's history a time so marked by various discoveries and inventions as the present day?

The wonderful grasp which man has obtained of force, of the origin of which he is ignorant and of which he yet makes excellent use for many purposes which were utterly inconceivable a few months or years since, absolutely throws into insignificance the hopes of those who desire, by mechanical means alone, to apply to the air the same conditions imparted to it by the mechanical wing-action of the bird, by which it sustains in motion a weight out of all proportion, in human conception,

to the surface of its wing; yet in exact proportion to the requirements of sustentation and progression in the atmosphere. The mechanical conditions of flight must, therefore, be thoroughly understood before they are attainable.

To imitate Nature is a natural and laudable aspiration, and it would appear more hopeful to strive after success in obedience to a precedent, than to attempt to put in harness an unknown power for the accomplishment of objects for which in Nature there is no visible or tangible precedent whatever.

I venture to say that if certain recent discoveries had been published for centuries previously, as objects to be attained by constant study and application, the uninstructed portion of mankind would have held in derision the notion of a future for the electric telegraph, the phonograph, the phonoscope, and the telephone.

Resistance is no less caused by a surface in motion against the air than by the air in motion against the surface. With this great advantage in favour of the surface moving against the air, that the speed and pressure can be regulated to the point of efficiency and safety. It is this resistance which the bird creates for itself in the calm of a sultry summer's day by the agitation of its wing-surface; in obedience to which certain mechanical actions are evoked, tending to impel it through the still air. The resistance to the down-stroke of the wing and the resistance to the up-stroke are resolved into a sustaining and propelling power. It is conceded that any mechanical contrivance which will cause the resistance encountered by the up- and down-stroke to be resolved into a single force, must in air have the effect of flight, other matters being in accordance.

But, apart from theory, let us see what is the precise action of the air when agitated by the up- and down-stroke of a wing. We need not theorize here—we can submit the matter to ocular demonstration, and the effect is conclusive as well as surprising. Not to my knowledge has any similar explanation been afforded.

Take the natural wing of a bird—in my experiments I used the wing of the carrion crow, in length twenty inches—approach a gas flame, and wave the wing, presenting to the flame the anterior edge, commencing at the base, and drawing it towards you until the tip is reached. It will be observed that the flame is sucked in underneath the wing in both the up- and down-stroke throughout its whole length. Now present to the flame the posterior edge; the same action is observable in both the up- and down-stroke, until near the tip, where the flame will alter its behaviour and be forcibly expelled, the strong current effecting sometimes its extinction.

Here we have the bulk of the wing-surface rendered effective in support, in both the upward and downward action, whilst towards the tip of the wing resides the propelling action.

The great difficulty which the inventor has met with in his desire to encounter the atmosphere in the manner of a bird has faced him at the very first step; it is, we may say, the goose step, the first step in flight—flight itself by simple wing action. We have, however, latterly attained to this, and have thereby assured ourselves that those natural flying machines—the birds—are not supported and propelled by some occult agency unrecognized in any school of science.

That no highly rarefied air in or about the body of the bird is essential to flight.

That no arrangement of feathers so that in the upward stroke the air shall pass through them, whilst in the reverse stroke they shall be impervious to its passage, is necessary to accomplish an imitation of flight. I have shown many examples. When, however, we come to the transport of weight by such artificial means—such weight, for instance, as is presented by the living prototypes whose shape and proportion of wing we attempt to imitate, such as the rook, the blackbird, swallow, or albatross, with twelve feet stretch of wing—we become perplexed, or, rather, we have hitherto been perplexed, because it is the object of this paper to show that this difficulty is receding before the more perfect knowledge which is always attainable by those bulldogs of science who are determined to retain their grip of an object of which they have once realized the flavour.

Experiments with the wings of the dead bird have hitherto been unsatisfactory.

I have myself not been successful in attaining flight by the attachment to my apparatus of any birds' natural wings. I attribute this to the absence of that elasticity which pertains to the living prototype. The best examples of flight by models, which I have yet attained, are in those instances where the wings have been made more than usually flexible. This is an encouraging feature, because the manufacture of a rigid wing of the dimensions necessary to support a man would necessitate great weight; in fact, it would be impossible to control its action by any motive power without great danger of fracture. I have seen such a wing fractured at the first stroke.

The apparently insuperable difficulties attending the accomplishment of manual flight by wing action have stimulated efforts in the direction of plane surfaces propelled by screws.

The late Sir George Cayley, a Yorkshire baronet, well known for his persistent experiments for the attainment of locomotion in the air, states, with respect to plane surfaces, "About sixty years ago, many experiments on a large scale were made by this means, some of the aërial vehicles having three or four hundred feet of canvas extended on masts, and braced by rigging, and

a surface of fifty-four square feet, weighing 11lbs., was found to support 126lbs. in its waft. These trials proved in a most decided manner that perfect stability and guidance were attainable.

"For instance, it was proved that a man placing himself on a machine of proper dimensions for his weight, at the top of a mountain, say one mile above the level of the plain below, might in calm weather, with steadiness and security, proceed through the air to any place he might choose to steer, about eight miles in a horizontal direction. Of course the line of flight would be in a continuous descent of 1 in 8, gravity being the only cause of the motion of the machine."

So that the propulsion of such a surface is not a preposterous idea. Mountain tops, however, are ideal in the majority of localities, so that, in order to find a substitute for that rarity, it was gravely proposed by a gentleman who called himself a civil engineer, that the line of flight being first determined upon, high towers should be erected at suitable distances, from the top of which a machine of considerable dimensions, with passengers, might be started, and so steered to the foot of another high tower, to the top of which the machine could be hauled, while the passengers walked up the stairs, and were launched to the foot of the next high tower!

To avoid high towers and mountains must of necessity become the aim of the plane-propeller, and there is just this difficulty, Can he by any auxiliary power leave the ground by rising in the line of least resistance?

Well, this has never yet been accomplished. No speed that has yet been attained on the level road, or even down an incline, has hitherto proved sufficient to enable a surface advanced at any angle against the air to leave the ground and complete its flight in the air. Of course there is a velocity relative to weight and surface which will affect this achievement, and as an experiment it will no doubt be effected, but when done it will only class with balloon propulsion. It has been shown that, as a fact, the balloon can be propelled, and when the attainment of a speed of six or eight miles an hour in a moving body of air of varied velocity, whose direction may or may not be in favour of the desired course, will conduce to the object sought, then the knowledge may prove useful, and the expenses connected therewith may count for nothing in view of its importance.

That which I have advanced respecting the plane relates only to the stiffened plane surface propelled at a fixed inclination against the air. The conditions would, I believe, be quite altered if the plane surface could be made to assist itself during its preliminary run; and I think that I am justified in my

opinion by reference to some long-winged birds that effect their rise from the ground, not alone by extending the wings as planes, but by using the air as a fulcrum which is increased in solidity by the multiplication of the vibratory wing-action.

Mr. F. H. Wenham, in the first paper read before the Aëronautical Society, speaks of the eagle which he sees sitting in solitary state in the midst of an Egyptian plain.

"An approach to within eighty yards arouses the king of birds from his apathy. He partly opens his enormous wings, but stirs not yet from his station. On gaining a few feet more, he begins to *walk* away. Now for the chance fire. A charge of No. 3 from 11 bore rattles audibly but ineffectually upon his densely feathered body. His walk increases to a run, he gathers speed with his slowly waving wings, and eventually leaves the ground. Rising at a gradual inclination, he mounts aloft, and sails majestically away to his place of refuge in the Lybian range, distant at least five miles from where he rose. Some fragments of feathers denote the spot where the shot had struck him. The marks of his claws are traceable in the sandy soil, as at first with firm and decided digs he forced his way, but as he lightened his body and increased his speed *with the aid of his wings,* the imprints of his talons gradually merged into long scratches. The measured distance from the point where these vanished to the place where he had stood, proved that, with all the stimulus that the shot must have given to his exertions, he had been compelled to run full twenty yards before he could raise himself from the earth."

Thus Nature teaches us; but there is such an infinite variety in the mode of flight, and in the manner of progression, both in water and in air, that though we may never get the proverbial pig to fly, we may possibly be able widely to depart from any known form.

The difficulties which inventors have foreseen, and sometimes encountered without foresight, are—the construction of wings which shall be of the great lateral extension considered to be necessary;—strength of structure;—ability to manipulate them. The preservation of a certain amount of rigidity throughout the whole length, decreasing towards the tips, and especially so between the anterior and posterior portions of the wings' edges —the great strain upon the posterior edge, which cannot be framed to any attachment without destroying the whole principle of action—and the small amount of sustaining surface by reason of the comparative narrowness of wing, under which it is impossible to see safety unless by the preservation of an acrobatic balance.

All these considerations have militated against the employment of wings for progression and support upon the air.

It is evident that if the wing surface could be extended longitudinally and there attached, something like the small end of a kite, to the extremity of its backbone, thirty feet behind, the surface thus exposed might be made ample enough to sustain man and motive power. In fact, it would be easy so to extend 300 or 400 feet of canvas by wing arms, twenty feet long from tip to tip; but *the surface would not be in tension.*

It may have been observed that the best flying kites are those which "belly" with the wind, or in other words, form a concave towards the wind. Would such an arrangement prove effective? If so, then I can see safety under such an extent of surface. I can also see that this surface would take a concave form in its descent, and so prove to be a longitudinal parachute which would bring a weight down in perfect safety.

Is there any example in Nature which would warrant the supposition that such an arrangement would be effective? Well, if we go to an aquarium, and watch the mode of progression of some fishes, we shall find that some of the flat-fish—notably the skate—progress by a wave-like action of the whole of their bodies. We cannot, of course, impart a wave action to the framework which shall extend our canvas, but we can do so to the canvas, and the question arises, Will a surface so vibrated support as well as propel? I can aver that a model made upon this principle, which I discovered for myself, behaved in a perfectly satisfactory manner. The wave action is imparted to it by the vibration of two wing arms, which cause a succession of waves to flow from the front to the extreme end; and I find that it will not be difficult to manufacture those arms twenty-four feet from tip to tip, light, elastic, and incapable of fracture, consisting, as they will, of bundles of canes wrapped together firmly, from base to tip, with whipcord, and tapering the whole by cutting off a cane every foot or so. My idea is, that if the whole were placed upon wheels, and a wave action imparted to the fabric by steam or compressed air, it would perform much the same feat as Mr. Wenham's eagle. The parachute action upon cessation of motion leaves nothing to be desired, amenable as it is to proper management in the disposal of the ballast.

The sustentation of a weight in flight by wing action depends entirely upon power, strength of material, and surface. As power and strength are increased, the surface may be curtailed. I scarcely, however, dare to hope for any such result as spoken of by Sir George Cayley, for in that case I might expect that 400 square feet of canvas would support more than 800 pounds.

The surface, however, being its own propeller, satisfactory results may be expected. I have a model, for instance, of the dimensions of an albatross. Now if it is supposed that a fabric

is attached to the wings, from tip to tip, and from thence taken to the tail, we should then have a comparatively loose surface, having no intermediate support but that afforded by the central shaft. Upon the waving of the wing arms we should then get a wave action longitudinally as well as laterally.

This double action proving effective we might then have above us a cloud of canvas, supporting and propelling, and presenting an extent of surface that would look more like safety than anything which has hitherto come under my notice. To these advantages may be added the statement that for aërial transit it would be only necessary to clear obstructions, and that those highly-coloured pictures of so-called "aërial machines," "up above the world so high," do not represent faithfully our aspirations.

I have now given the reasons for the ambitious hopes that some of us entertain, and I conclude with the expression of a desire that more minds may be directed to the attainment of our objects.

REVIEWS.

FRANKLAND'S EXPERIMENTAL RESEARCHES.*

IT is not often that a man, who has only just passed the meridian of life, can point to so huge a mass of original work as is represented by the noble volume which Dr. Frankland has placed in our hands. For upwards of thirty years this distinguished chemist has successfully devoted himself to the prosecution of experimental inquiries, and has naturally contributed, during this period, a large number of memoirs to the transactions of our learned bodies, especially to the Royal and the Chemical Societies. Looking back upon the accumulated labours of his life, he has deemed it well to gather up these scattered fragments, and to piece them together in connected form. But it must be remembered that the author has done much more than simply collect and co-ordinate his memoirs. To each chapter of his work he has prefixed an introduction, indicating its scope, and pointing out the connection of the several papers one with another. Those who are interested in chemical science—whether, in its pure, its applied, or its physical aspect—will assuredly be grateful to the author for presenting his work in so complete and compact a form.

How great a revolution has swept over chemistry since the earliest of Dr. Frankland's papers were published! A young chemist, fresh to-day from the laboratory and the lecture-room, and who has read only modern text-books, could scarcely understand a memoir written thirty years ago; and, on the contrary, if a chemist of that period had fallen asleep, and could be aroused to-day, he would find our modern memoirs equally unintelligible. The current of chemical thought has, in fact, been flowing in new channels; the notation formerly in vogue has been completely altered; the very language of the laboratory has changed. Above all, the idea of atomicity or quantivalence, an idea which lies at the root of modern chemistry, had not been conceived thirty years ago; and the reproduction of these memoirs reminds one of the part which Dr. Frankland has played in introducing this conception to the scientific world. Fully admitting what has been done by such men as Kekulé and Cannizzaro, it must be conceded that the germ of the modern doctrine, the root of the new theory, was due to Frankland's remarkable studies of the organometallic bodies.

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* "Experimental Researches in Pure, Applied, and Physical Chemistry." By E. Frankland, Ph. D., D.C.L., F.R.S., &c. 8vo. London: Van Voorst, 1877.

In order to secure uniformity in the work which is now before us, Dr. Frankland has so modified some of his early papers as to bring them into accordance with modern ideas. In transcribing these memoirs he has naturally followed his peculiar system of notation. This we of course expected to find; but, nevertheless, we cannot help regretting the step. In fact, ingenious as Frankland's system unquestionably is, it may be fairly doubted whether it is destined to survive its author; and it is certain that it never would have attained to its present position, had it not been for the very influential position which he occupies, and the power which he thus has of leading most of the younger chemists. As a matter of course, the pages of the massive volume in our hands are freely besprinkled with those obtrusively thick symbols which stand as initials to indicate the elements of highest atomicity in the formulæ, and with those confusing little o's, which enter so commonly into the formulæ of the metallic radicals, and are the pest of a printer.

Dr. Frankland's researches naturally arrange themselves in the form of a triad, dealing as they do with Pure, with Applied, and with Physical Chemistry. In the department of pure chemistry, we find those famous organic researches, partly analytic and partly synthetic, on which Frankland's fame was originally built, and will always rest. In the applied section we have not only his well-known studies on gas illumination, but also those investigations on the pollution and purification of water, by which Dr. Frankland's name is everywhere known. Finally, in the physical group of papers we meet with a reproduction of his researches on flame—those researches which have sometimes been cited to disprove the long-established results of Davy.

On closing this work, which runs to upwards of a thousand pages, we must admit that it is anything but light reading. The volume belongs, in fact, to the class of books which Dr. Johnson described as being "more easy to praise than to read." Still, so many of Dr. Frankland's researches have become classical, that the work in which they are reproduced should at once take a place in every chemical laboratory and library.

GEOLOGY OF IRELAND.*

THIS little work is well printed, prettily illustrated, and altogether tastefully got up; but having said this, we are unable to add much else in its favour. The object of the writer has been to present the outlines of geological science in simple fashion, and with special reference to the rocks which occur in Ireland. It is to be regretted, however, that before undertaking this task, he did not prepare himself by a deeper study of his subject. Whether in its geology, its palæontology, its mineralogy, or its chemistry, there is much in the book to which we are bound to take exception. What, for instance, can be more absurd than the statement that basalt "consists

* "Outlines of Geology, and Geological Notes on Ireland." By William Hughes. Third edition: revised, considerably enlarged, and with numerous Illustrations. Sm. 8vo. Dublin: M. H. Gill & Son, 1879.

principally of silica, oxide of iron, felspar, pyroxene, alumina, and lime?" It is scarcely conceivable that a writer on geology should have so little knowledge of the composition of a common rock, like basalt, as to mix up the mineralogical and chemical constituents in this ridiculous way. But while we are unable to recommend the work as a safe guide to the student, we admit that some parts are pleasantly written, and may be read with interest by anyone who requires only a superficial view of geology. It should be noted that the work is provided, as we are told in large letters on the title-page, with "an addenda!"

BEE-KEEPING.*

ALTHOUGH we cannot pretend to an acquaintance with all the published manuals of Bee-culture, whose name is legion, our acquaintance with apiarian literature is sufficient to enable us to form a pretty good judgment of the merits of Mr. John Hunter's little "Manual," a third greatly improved edition of which has just been published. Mr. Hunter gives a brief sketch of the natural history of the Hive Bee, in which, without going very profoundly into the matter, he furnishes his intended readers, the practical apiarians, with just that amount of information which will enable them to understand the management of their hives and take an intelligent interest in the doings of the little inhabitants. He especially expounds in a very clear and easily intelligible fashion the modern theory of the reproduction of Bees, founded by Berlepsch and Siebold upon their own researches and those of Dzierzon.

Bee-keeping has made rapid advances during the last few years both in Europe and America, and the inventive genius of our cousins on the other side of the Atlantic has been greatly exercised in the construction of numerous ingenious appliances for the better management of the Bees, including the observation of their doings, and for facilitating the winning of a harvest of pure honey without having recourse to the old barbarous process of destroying the industrious insects which produced it. Of the success of these devices we have abundant proof in the quantities of honey and clean honeycomb which have been of late years imported from the United States; and one of Mr. Hunter's objects in preparing his little book is to transfer some portion at any rate of the profits of the honey market to the pockets of his own countrymen. With this view he describes very clearly the best methods of managing Bees, and devotes very considerable space to the consideration of various forms of hives, in which we are glad to see that he regards simplicity of arrangement as one of the most desirable characteristics, considering that many of the supposed improvements which have been lately introduced, are chiefly adapted "to increase expense, and confuse the unfortunate tyro in Bee-keeping." In other chapters the actual management of the insects with the view of securing the greatest amount of profit from their labours is very fully and lucidly explained; and of all the "Bee-books" that we have seen,

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* "A Manual of Bee-Keeping." By John Hunter. Third edition. Sm. 8vo. London: D. Bogue. 1879.

this seems, from its straightforwardness, and from the care with which the author has made use of recent contributions to apiarian literature, to be the best adapted to enable anyone of moderate intelligence to carry on Bee-cultivation with success. Besides its technical use, however, the little volume will prove of considerable interest, even to the general reader, who will be rather surprised at the ingenuity of some of the devices employed for the profitable government of the hive, which used to be regarded as a model republic. Andrew Fairservice, it will be remembered, described Bees as a "contumacious generation," because "they hae sax days in the week to hive on, and yet it's a common observe that they will aye swarm on the Sabbath-day, and keep folk at hame frae hearing the Word." Had he lived in the present day, he would have learned that it was possible to make them swarm when he thought it most desirable. But the most remarkable interference with the internal economy of the hive is the actual regulation of the constitution of its population, by the introduction of "foundation combs" fixing the size of the cells to be constructed, and consequently, in a hive with a healthy queen, the nature of the progeny to be reared.

The little book is well and copiously illustrated.

GANOT'S PHYSICS.*

WHEN a work has attained to the position as an educational text-book that is enjoyed by Dr. Atkinson's English edition of Ganot's "Elements of Physics," the reviewer's work, as each successive issue makes its appearance, is reduced to a minimum. For all practical purposes, a mere statement of the fact is sufficient, and we have much pleasure in announcing the publication of a ninth edition of the above-mentioned admirable handbook. In this, as in each previous issue, the bulk of the book has somewhat increased, so that it now constitutes a very stout volume, tending in fact to become portly with advancing years. In the present edition we find, besides a great number of minor alterations and additions scattered throughout various chapters of the book, very clear and explanatory descriptions of those curious inventions which have made so much noise in the world during the last few years, such as the telephone, microphone, tasimeter, and phonograph; the electric light also comes in for its share of attention; and these popular subjects seem to occupy about half the twenty-five pages which, as Dr. Atkinson tells us, have been added to the bulk of the volume.

GRAY'S BOTANICAL TEXT-BOOK.†

AFTER the lapse of two and twenty years, the veteran American botanist, Professor Asa Gray, has commenced the publication of a new (sixth)

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* "Elementary Treatise on Physics: Experimental and Applied." Translated and Edited from Ganot's "Eléments de Physique," by E. Atkinson, Ph.D., F.C.S. Ninth Edition, Revised and Enlarged. 8vo. London: Longmans. 1879.

† "The Botanical Text-book." Sixth edition. Part I.:—Structural Botany or Organography on the Basis of Morphology, &c. By Asa Gray, LL.D. 8vo. New York and Chicago: Ivison, Blackman, Taylor & Co.; London: Trübner. 1879.

edition of his well-known "Botanical Text-book." The foundation of this elaborate work is to be found in a small book published under the title of "Elements of Botany" more than forty years ago, which was followed in 1842, the year in which the author entered upon his professorial duties in Harvard University, by the first edition of the "Botanical Text-book." In this, as in the present issue, the author founds all his work on a morphological basis, a mode of treatment which was novel when first adopted by him, but which most recent writers on the principles of botany have adopted.

By the development of the subject, and perhaps of the ideas of the author, the plan of this sixth edition has been much enlarged. Instead of a single volume it is to consist of four, the first of which only is now before us, devoted exclusively to structural botany and the principles of systematic botany, with reference, however, solely to phænogamous plants. The treatment of the subject is the same as in former editions, proceeding from the organography of the seedling plant to trace the structure, form, and arrangement of all the parts to be developed from it, but in the details we find much that is new, as might indeed be expected from the advances that have been made in botany, as well as in other departments of Natural History, in the last twenty years. Thus, to take a single example, we find an entirely new section introduced, dealing with the various adaptations of flowers for intercrossing and close-fertilization, in accordance with the views so convincingly put forward by Mr. Darwin in various works, and supported by an immense body of observations recorded by other naturalists, now constituting, as our author says, "a copious special literature."

In the chapter devoted to Taxonomy, or the Principles of Botanical Classification, the author expounds his views upon the origin of species. He accepts the doctrine of evolution in the following sense: Variation, "if sometimes called out by the external conditions, is by way of internal response to them. . . . Each plant," he holds (with Nägeli), "has an internal tendency or predisposition to vary in some directions rather than others; from which, under natural selection, the actual differentiations and adaptations have proceeded. Under this assumption, and taken as a working hypothesis, the doctrine of the derivation of species serves well for the coordination of all the facts in botany, and affords a probable and reasonable answer to a long series of questions which without it are totally unanswerable. It is supported by vegetable palæontology, which assures us that the plants of the later geological periods are the ancestors of the actual flora of the world. In accordance with it we may explain, in a good degree, the present distribution of species and other groups over the world."

The tenth and last chapter in the book deals with Phytography, or the nomenclature and method of describing plants, and includes also a few remarks on the formation and management of the herbarium, and a list of the usual abbreviations of the names of botanical writers. A copious glossarial index concludes the volume, which is beautifully printed and copiously and well illustrated. As the author says in his preface, "It should thoroughly equip a botanist for the scientific prosecution of systematic botany, and furnish needful preparation to those who proceed to the study of Vegetable Physiology and Anatomy, and to the wide and varied department of Cryptogamic Botany." These two branches of the science constitute the subjects

to be treated of in the next two volumes, the preparation of which has been handed over by the author to his colleagues, Professor Goodall and Professor Farlow. The fourth volume, giving a sketch of the natural orders of phænogamous plants, with other special information, Professor Gray says that he rather hopes than expects himself to prepare. We sincerely trust that this hope may be fulfilled.

THE CAPERCAILLIE.*

IT is so long since the present writer had the pleasure of seeing a certain book which once upon a time made a considerable noise in the world, namely, MacPherson's version of the Poems of Ossian, that he cannot say whether the Great Cock of the Woods figures therein, although his impression is that it does not. Nevertheless, there can be no doubt that this bird ought to have made his appearance somewhere in the poetical record of the doings of the Fingalic chiefs. In the days of Fingal he must have been abundant in many parts of Scotland, and as he inhabits, not the inaccessible summits of the mountains, but the wooded region near their foot, and, being nearly as big as a turkey, furnishes no contemptible supply of savoury food, we can hardly suppose that his body was absent from the feasts with which the warriors of those days prepared themselves for those copious libations of whisky (varied occasionally, no doubt, by a little dirk practice), in which they celebrated their feats of arms.

Even in later days the records of the occurrence of this grandest of all European game birds in Scotland are of the scantiest description, and the earliest of them, an often-quoted passage from the description of Scotland by Hector Boetius, dates only from 1526. From this time down to 1760, about which date the species appears to have become extinct, we have only a few scattered references to the existence of the bird in Scotland. Of its presence in Ireland, the evidence, although sufficient, is still more scanty. The earliest references are those of Giraldus Cambrensis, and Higden, the monk of Chester (1357–1387), both of whom mention "pavones silvestres," which in all probability were Capercaillies. In Ireland also the species appears to have become extinct about 1760; although, according to one authority, the birds still existed in that country as late as 1787.

All the references to the former existence of the Capercaillie in the British Islands have been carefully brought together by Mr. Harvie-Brown, in his book, entitled, "The Capercaillie in Scotland;" in which he also discusses the origin of the names given to the bird, of which the most correct would seem to be *Capullcoille*, signifying "Horse of the Wood." By Boetius it is spoken of as the "Auercalze," which is interpreted in like manner, and this name is of interest from its connection with the German "*Auerhahn*" (Bison-cock), represented by the Latin word *Urogallus*, which was adopted by Linnæus as the specific name of this great grouse. Upon these and other critical points the reader will find abundant information in Mr. Brown's work.

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* "The Capercaillie in Scotland." By J. A. Harvie-Brown, F.Z.S. 8vo. Edinburgh: Douglas. 1879.

With regard to the extinction of the Capercaillie in the British Islands about a century ago, the author is of opinion that this was due mainly to "the destruction of great forest tracts by fire, the cutting down of the same by man. . . . . and the wasting away of the forests from natural causes, by the conversion of dry forests into bogs and morasses, and, resulting from this, the decrease of, and changes in, the food of the species," which, as is well known, consists for the greater part of the young shoots of firs and larches. The increase of population, no doubt also, as suggested by Mr. Colquhoun. may have had some share in bringing about the extermination of the Wood Grouse; but it is mainly to the destruction of the forests, with no adequate replacement by the systematic planting of new woods, that the author is inclined to ascribe the disappearance of the species. Some Irish writers of the last century who witnessed the extinction of the bird in Ireland, express the same opinion.

The most interesting and important part of Mr. Brown's book relates to the re-establishment in the British Islands of the great Wood Grouse, and is the result of a series of minute inquiries instituted by him with the object of obtaining precise information to be used by Professor Newton in his edition of "Yarrell's British Birds" now in progress. From this we learn that, after several unsuccessful attempts, a considerable number of the birds imported from Sweden were introduced on the property of Lord Breadalbane at Taymouth in the autumn of 1837 and the spring of 1838, and that the progeny of these and subsequent colonists have not only established themselves on a firm footing at the original locality, but have also, as detailed in the text, and shown very clearly on a small map accompanying this section of the book, spread in various directions over a considerable portion of east central Scotland. For the most part this redistribution has been effected by the birds themselves, and the means of watching in a convenient fashion the perfectly natural extension of a species over a large extent of country is thus afforded to the naturalist. The course of events seems to be somewhat as follows:—When the Capercaillie population of a given locality becomes too large for its resources in the way of food, some individuals (generally, if not always, females) start off in search of a new abode, at first naturally following the line of the valley in which they find themselves, but also not unfrequently taking a freer flight, sometimes to very considerable distances. The females usually precede the males by one or two years, and owing probably to this circumstance, hybrids between the Black Cock and the Capercaillie are not unfrequent in localities inhabited by the former. The establishment of the species generally takes place very soon after the arrival of the males.

On the mainland of Scotland unsuccessful attempts to establish the Capercaillie have been made in several of the southern and western counties, and notably in Ayrshire; but in the island of Arran they have been introduced by means of birds obtained from Taymouth and Sweden in 1843 and 1846.

The re-establishment in Britain of this fine game bird appears not to be regarded with unmixed satisfaction by all parties. At least two grievous charges are made against him—namely, that he causes considerable damage to young trees by feeding on their growing shoots, and that he drives away or otherwise causes a diminution in the number of the Black Grouse. Of

the first of these charges Mr. Brown does not, we think, wholly acquit the Capercaillie, although he argues strongly for its extenuation, urging especially that much of the actual damage is probably done by squirrels and other destroyers; whilst he inclines to think that a great deal of apparent damage is due to the fact that many nurserymen seem to supply planters with an inferior race of seedlings, which could never under any circumstances make good trees. Of the second crime charged against the Wood Grouse, on the other hand, our author thinks he is not guilty; and accounts for the undoubted decrease of the black game, which takes place in localities where no Capercaillie has yet shown his beak, by changes in the condition of the ground brought about by drainage and other improvements. We cannot follow Mr. Brown further into this interesting question, but will conclude by recommending all earnest ornithologists to buy his book and read it for themselves.

RECORDS OF SCIENCE.*

WE are glad to see that Mr. Spencer F. Baird continues, with the assistance—as he justly says—of eminent men of science, the publication of his excellent "Annual Record of Science and Industry." The volume for 1878 contains a useful summary of the progress of science during the year, carefully classified under the various departments, and each section bearing at its head the name of a *savant* by whom, or under whose superintendence it has been prepared. As a matter of course, it cannot be expected that every published scientific paper or work can be referred to in a summary extending only to about 620 small octavo pages; but, so far as the writer can judge from an inspection of those parts with which he is most familiar, the selection of articles to be noticed has been very judiciously made, and few important contributions to scientific literature are passed *sub silentio*. The summaries themselves are also very well executed. We would suggest, however, that the utility of the work would be greatly increased, if references were in all cases given to the sources of the various articles. The volume concludes with a Necrology and a Bibliography of "select" works in science.

BRITISH PLANTS.†

THE work of a catalogue-maker is generally regarded with but little favour, but there are few things for which the student of natural objects has more occasion to feel grateful, than the production of a judiciously prepared list of the subjects of his study. The writer of a manual, no doubt, performs a higher service to his fellow-workers, and his labours may often be wearisome enough, but he is at least sustained under their pressure, by a certain feeling

* Annual Record of Science and Industry, for 1878. Edited by Spencer F. Baird. 8vo. New York: Harper. London: Trübner, 1879.

† The Student's Catalogue of British Plants, arranged according to the Student's Flora of the British Isles, by Sir J. D. Hooker. Compiled by the Rev. George Henslow. 8vo. London: Bateman, Portland Town, 1879.

of doing something original, with which the compiler of a mere catalogue cannot console himself. The Rev. George Henslow has just put in this last claim to the gratitude of English botanists, by the publication of a "Student's Catalogue of British Plants," founded upon Sir Joseph Hooker's "Student's Flora," and indicating all the species and sub-species, and the chief recognised varieties of the "British Phanerogams" and "Vascular Cryptogams." The pamphlet has been privately printed, but Mr. Henslow has placed copies in the hands of a bookseller who will send them to purchasers by post.

CANADIAN PALÆONTOLOGY.*

FROM the "Geological Survey of Canada," we have received the first two parts of a work on the Mesozoic Fossils of certain outlying parts of the great region to which its investigations are devoted. In the first of these, published three years ago, Mr. J. F. Whiteaves describes and figures a series of fossil Invertebrata, chiefly Mollusca, collected by Mr. James Richardson, from the coal-bearing rocks of the Queen Charlotte Islands; in the second, the same palæontologist deals with the fossils of the Cretaceous rocks of Vancouver, and adjacent islands in the Strait of Georgia; these deposits also containing beds of coal.

In the case of the rocks of the Queen Charlotte Islands, the examination of these fossils is of particular interest, as they seem to show clearly that, so far as can be judged by their Fauna, these deposits occupy the same intermediate position between the Oolitic and Cretaceous series, as interpreted by European types, which seems to belong to several groups of rocks in other parts of North America. The general character of the Fauna appears to be like that of the Shasta group of California and British Columbia, of which the author thinks it will be advisable to regard them as representing one of the oldest members; at least, until further information on the deposits grouped together under the above name shall be obtained.

The fossils from the Vancouver district, on the other hand, are of unmistakable Cretaceous age, and are considered by Mr. Whiteaves to indicate that the deposits from which they are derived are the equivalents of the European Upper Cretaceous series; at least, so far as the four lower divisions which he distinguishes among them are concerned: with regard to three upper divisions, it is uncertain, at present, whether they are Cretaceous or Tertiary.

These publications on special departments of North American Palæontology will be of great interest in the discussion of the equivalence of the North American and European Cretaceous deposits, and in the solution of the great question of the sequence in time of the formations in various parts of the world, if that problem is destined ever to be solved. The total number of species noticed or described are 45 in the first, and 94 in the second part, and 17 species in each series are regarded as previously undescribed. These and the greater part of the known species are very well figured upon 20 plates.

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* Mesozoic Fossils, Vol. I. Parts 1 & 2. By J. F. Whiteaves, F.G.S. 8vo. Montreal: Dawson Bros., 1876 & 1879.

BURNHAM BEECHES.*

ANOTHER volume from the pen of Mr. Heath, the writer of several books on trees and ferns, which have been at different times noticed in our pages, has lately reached us, of which at least it may be said that "it is only a very little one," although we fear it can hardly hope for a much longer life than the unfortunate infant for whose appearance in the world the same excuse was made. It is indeed far from being one of the author's happiest efforts, and though we are assured that it has been written *con amore*, it seems to lack the freshness of his earlier works. Mr. Heath had, however, some claim to be heard on the subject, as it was through his representations to the Corporation of the City of London, that "the Beeches" were preserved from the inroads of suburban villa builders, and have now become for all time the property of the inhabitants of London. In the "Keepsake" of 1829, Henry Luttrell wrote of Burnham Beeches—

"O ne'er may woodman's axe resound,
Nor tempest making breaches,
In the sweet shade that cools the ground
Beneath our Burnham Beeches!"

to which Mr. Heath appends a note:—"O prophetic soul! a nineteenth-century population has re-echoed your wish, and a nineteenth-century Corporation of London has struck the woodman's axe from the woodman's hands. May the 'tempest' be equally merciful!" This is all very well, but we would venture to suggest that this verse contains no prophecy; and it is sincerely to be trusted not only that this charming spot will be spared by the tempest, but that it will also escape that utter desecration at the hands of a rabble of holiday-makers to which unfortunately some other recreation grounds for London are regularly subjected. Half the charm of rural and especially of sylvan scenery arises from the sense of comparative quietude and seclusion; and if swings, roundabouts, and donkey drivers once gain a footing in the Burnham Paradise, most of us will be inclined to echo the closing words of the "poet" just quoted, and say

"Farewell to Burnham Beeches!"

Mr. Heath's little volume is very prettily illustrated, chiefly with woodcuts from his namesake's beautiful photographic views. He also gives an outline map of the locality.

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* "Burnham Beeches." By Francis George Heath. 8vo. London: Sampson Low, Marston & Co., 1879.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

Brachycephalism and Civilization.—Professor Virchow has suggested that dolichocephalous races may become brachycephalous by the sole agency of civilization. To test this view, M. Luschan has undertaken a number of investigations into the contents of the great ossuaries of the German provinces of Austria, dating back to the fifteenth and sixteenth centuries, and communicated his results summarily to the French Association for the Advancement of Science (1878, p. 825). At Mödling, in Lower Austria, he found the crania of the fifteenth century of a very pure dolichocephalic type with a mean index of 68. The present population of the village is brachycephalous, with a mean index of more than 80.

Analogous results were obtained in many ossuaries in upper and lower Austria, in Carinthia, and in Salzburg. But in others, such as that of St. Peter im Holz, near Spital, in Carinthia, all the crania from the sixteenth century down to the present day were dolichocephalous. Now the population of St. Peter im Holz has the same schools, the same language, the same laws, and the same degree of civilization as that of Mödling; and it is consequently hard to say that at Mödling the crania have become brachycephalous by civilization, whilst under the same conditions, they have remained dolichocephalous at St. Peter.

There must therefore be another cause for brachycephalism being so prominent in many parts of the German provinces of Austria. According to M. Luschan, wherever brachycephalous crania are found, the state registers show Sclavonic names, and it may be ascertained in all cases either from history, or from the registers, that a more or less abundant Slav immigration took place into them during the sixteenth century. Some ossuaries in Bavaria have furnished the author with similar results. He regards it as certain that in Austria brachycephalism has been produced not by civilization, but by Slavs; and he thinks it very unlikely that the Prussians have acquired their remarkable brachycephalism solely by the influence of culture and civilization.

The Age of Stone in China, and the Chinese Origin of the Cremation of the Dead.—According to M. Zaborowski (*Assoc. Franc Avancem. Sci.*, 1878, p. 835), the age of stone was only a matter of tradition in China at the earliest period of history, and even then this tradition was coupled with

superstitions. The historians, however, state that Chin-noung (B.C. 2737), and Hoang-ti (B.C. 2697), still employed stone in the manufacture of their weapons. But as early as the reign of the latter prince, the rebel Tchi-Yeou of the country of Kiou-li made use of metallic arms. In the Chou-King it is stated that in the time of Yu (B.C. 2200), the savages near the rivers Ho and Kiang brought as tribute, *iron, silver, steel, and stone arrow-heads.* The last were therefore already regarded as rare and precious objects, as they were at a later period, to judge from an anecdote here related. In the year 495 B.C., Confucius being at the court of Tchin, a bird pierced by an arrow with a stone head, fell upon the terrace at the feet of the King, who seems to have been rather alarmed, and consulted Confucius on the subject. The philosopher told his majesty that the arrow-head was exactly like that which Wou-wang had presented as a symbol of royalty to the prince, for whose benefit he founded the kingdom of Tchin. The King, searching among the precious relics of his ancestors, actually found a stone arrow-head.

In the history of King-Tcheou, it is related that a block of granite existed in the district of Sin-ho, still having traces of the polishing of stone implements; the inhabitants called it "the dormant mill of the thunder god." It is curious to find this association of stone implements with thunder prevalent in China as in Europe. Among some pretended celestial presents brought to the Emperor Sou-Tsoung (A.D. 756–762) by a Buddhist priest, there were two fragments of jade forming a polished hache, which bore the designation, "stones of the thunder god." The very great antiquity of the civilization of China is regarded by M. Zaborowski as an additional proof of the great lapse of time that must have occurred since the use of stone implements was general there.

With regard to the cremation of the dead, M. Zaborowski remarks that this practice spread over Europe at the commencement of the Bronze age, and that it did not come to us from Egypt or Phœnicia, as neither the Egyptians nor the Phœnicians burnt their dead. On the other hand, cremation was practised in India from the most remote antiquity, and in China it appears that before the year 1122 B.C., straw men destined to be burnt were carried in funerals, but at that date these were replaced by wooden figures. Confucius refers to this change in terms which show the religious nature of the practice; he says: "Those who made *spirits* of straw were regular; those who made men of wood were irregular." The practice seems to symbolize a still older one of burning the body itself.

At the present day in China cremation is rare, and the remains of the dead are only burnt at the end of a year. But the practice prevails in Cochin-China; and in the time of Marco Polo it was in use all over the extreme east of Asia, where it may be supposed to have existed from the earliest times. From this same region, he believes, the bronze industry came into Europe.

Capacity of the Cranium in Man.—M. Anoutchine has found reason to doubt the absolute truth of the maxim that in the human species the most voluminous crania belong to the most intellectual races, and in each race to the most intelligent individuals. In support of this opinion he gives the following list of cubic contents from various authorities, but all taken by the same process:—

	Cub. cent.		Cub. cent.
Germans (Weissbach) . .	1,521	Russians (Lauzert) . . .	1,471
„ (Welcker) . .	1,448	Tchuktchi (Wyman) . .	1,468
Croats (Weissbach . . .	1,499	Slovaves (Weissbach) . .	1,467
Kalmuks (Metschnikoff) .	1,498	Czèchs (Weissbach) . .	1,456
Chinese (Lucæ)	1,482	Hungarians (Weissbach) .	1,437
Roumanians (Weissbach) .	1,478		

The Kalmuks and Chinese have a greater volume of the cranium than several European nations, and the Tchuktchi are larger than the Hungarians. The large size of the heads of the Kalmuks has been observed by several voyagers, and proved by actual measurement by Metschnikoff and Von Baer.

With regard to the pre-historic races of Europe, M. Anoutchine thinks we cannot say absolutely that the volume of the cranium was less in them than in modern races. The mean volume of the cranium in modern Parisians is 1,558 cub. cent. (in the women, 1,337). Of pre-historic crania we have:—

	Cub. cent.
Cranium of Cro-Magnon	1,550
„ „	1,590
„ Grenelle	1,530
„ L'Homme Mort. . . .	1,606
„ La Truchère (estimated) . .	1,925
„ Solutré	1,560
„ „	1,428
„ Furfooz, Young . . .	1,300
„ „ Female . . .	1,450

Thus these pre-historic people do not appear to have had a cranial capacity decidedly less than that of the existing Parisian. In the race of Canstatt, and the Neanderthal man, we have a different state of things, the latter being estimated to have had a cranial capacity of not more than 1,200 cub. cent. But this character may have been individual and exceptional, just as Kay Lysse, a Dane who played an important political part in his country, had a capacity of only 1,250 cub. cent.; and Luschan has measured the brain of a Hungarian of only 1,195 cub. cent.

As regards the difference in volume of the largest and smallest adult male crania, and its supposed increase with the civilization of the race, M. Anoutchine points out that although Le Bon has found this difference to be 592 in modern Parisians, and only 472 in the Parisians of the seventh century, whilst in the Australians it is only 284, Mantegazza has found a difference of 533 among the Papuas of New Guinea, and Metschnikoff one of 539 among the Kalmuks. Nor does he think it an absolute fact that the difference of volume between the male and female crania is much greater in civilized nations than among half-savage peoples. Thus Welcker finds, by the comparison of thirty crania of each sex, that the mean difference among the Germans is 148 (1448–1300), and Mantegazza gives it as 140 (1425–1285) among the Papuas. The two numbers approach closely, but the difference in the civilization of the two peoples is immense.—(*Assoc. Franç. Avancem. Sci.*, 1878, p. 863.)

Anthropometry.—The Anthropometric Committee of the British Association appointed for the purpose of making a systematic investigation of the heights, weights, and other dimensions of the human inhabitants of the empire, laid their report before the Association at the last meeting. They stated that considerable progress had been made in carrying out the objects of the Committee during the past year, returns having been obtained giving the birth-place, origin, and sex, age, height, weight, colour of hair and eyes girth of chest, and strength of arm and eye-sight, of a great number of persons, including pupils at Westminster and other schools, London policemen and letter-sorters, rifle volunteers, soldiers, and criminals. The Committee had thus procured nearly 12,000 original observations on the question of height and weight in relation to age, in addition to 50,000 previously collected. From tables embodying the results of these inquiries, it appeared that the London letter-sorters were the lowest in height, the average between the ages of 20 and 35 being 64–67·1 inches. They were also the lowest in point of weight, being only from 122·5 to 139·9 lbs. The metropolitan police stood at the head of both lists, height 69·2–71·5 inches, and weight 162·5–182·7 lbs. From other tables it appeared that the average of weight and height varies with the social position and occupations of the people, so that to arrive at the typical proportions of the British race, it would be necessary to measure a proportionate number of individuals of each class. Taking the census of 1871 as a standard, a model community should consist of 14·82 per cent. of the non-labouring class, 47·46 per cent. of the labouring class, and 37·72 per cent. of the artizan and operative classes. The nearest approach to such a representative population will be found in some of the larger county towns, such as York, Derby, and Exeter. In the professional class the full stature is attained at 21 years, and in the artizan class between 25 and 30 years. According to some American statistics a slight increase in height takes place up to the 35th year. The growth in weight does not cease with that of the stature, but continues slowly in both classes up to about the 30th year. Similar investigations which have been made in other countries have led so far to coincident results that it is hoped that, in course of time, information of great value will be elicited.—(*Nature*, 18 Sept. 1879.)

Date of the Neolithic Age. In a paper read before the Biological Section of the British Association, Mr. S. B. J. Skertchly propounded a new estimate of the date of the Neolithic Age, based upon calculations made in the Fenlands, occupying an area of 1,300 square miles, around the great bay of the Wash. The surface of the inland portions of this area consists of peat, and that of the seaward parts of marine silt. This silt is still in progress of deposition, and, from the time of the Roman occupation at least, banks have been successively erected to reclaim the newly-formed ground; and, as the dates of these banks are known, very accurate estimates can be formed of the rate at which the deposition is going on in different parts. The maximum rate is, according to Mr. Skertchly, fifty-nine feet per annum; and four miles of new land have been formed since the oldest banks were erected. These banks are generally ascribed to the Romans, but the author considers that they are probably British. In forming his estimate, he has, however, taken them as Roman, in order that their age may not be over-estimated, and the

maximum rate of deposition has also been used, as giving the minimum of time. He considers that the geological evidence shows that as the silting went on, and the area became converted into land, peat grew, and gradually spread over the newly-formed ground. But, in process of time, the climate became unsuited for the growth of peat, which gradually lost its vigour, and finally ceased to form. Hence a wide stretch of silt-land borders the Wash, upon the surface of which no peat has ever formed. The peat died upon its eastward march; the silt still travels on. The nearest approach of the peat to the banks along the line of most rapid accumulation, is twelve miles distant therefrom. The age of this, the newest peat in the Fenland, the author thinks can be thus determined. Between the "Roman" banks and the sea lie four miles of silt, which has taken 1,700 years to accumulate. Between these banks and the peat lie twelve miles of silt, which, at the same rate of formation, would take 5,100 years to accumulate. Adding 5,100 to 1,700 years, the author finds 6,800 years as the least possible age of the newest peat. This peat has yielded many neolithic implements; hence we may assume that 7,000 years will take us back into the neolithic age. The author remarks upon the coincidence of this estimate with two Swiss ones previously referred to, but observes that these results do not give us the date of the introduction of neoliths into Europe, for neither in the Swiss nor English localities are we sure that the neolithic relics belong to the early part of the neolithic age. The author further states that he has recently obtained evidence of neolithic handiwork in Fenland peat of far greater age than that described; the peat-bed underlying silt more than 7,000 years old. He is inclined to think that the neolithic age in England began at least 10,000 years ago—and perhaps 20,000 years; but that it does not approach the close of the glacial epoch, he thinks is shown by the fact that the older Fenland beds (themselves in part glacial) do not contain human relics.

ASTRONOMY.

Biela's Comet.—It is well known that when this comet returned to perihelion in 1866 and again in 1872, the heavens were searched in vain for it, by many of the most careful and trustworthy observers. It seems exceedingly unlikely that telescopists will meet with greater success this year. Calculation seems set completely at defiance. In the first place it is to be remembered that every return of this comet increased the accuracy with which its orbital motions were known. So that as it had been at once identified in 1846 and again in 1852, astronomers had every reason to expect that it would be much more easily found in 1866 (in 1859 its geometric path brought it too near the sun's place in the heavens for a successful search to be instituted). In 1872 the chance of finding it had only so far diminished, that the failure of astronomers showed that something had gone wrong. There was good reason to believe that the failure to recognize the comet did not in any way arise from unknown perturbations to which the comet had been subjected, but from a further disintegration of the comet's substance, already so far effected that since 1846 this object had in reality become

two distinct comets. Now some ten or twelve months after the comet had (according to the calculations of astronomers) passed the part of its orbit which intersects the earth's track (or at least passes very close to it), the earth herself came to the corresponding part of her orbit—that namely which she passes on or about November 26, 27, and 28. There then occurred, as had been predicted by Professor Alexander Herschel, a shower of meteors, in which some tens of thousands of small shooting stars were seen, radiating from a part of the heavens near the feet of Andromeda, and thus corresponding with the course which bodies following in the track of Biela's comet would pursue on the sky if they entered the earth's atmosphere when she is in the part of her orbit crossing Biela's. Klinkerfues, assuming that this cloud of meteors was Biela's comet itself, telegraphed to Mr. Pogson, Government Astronomer, at Madras, to examine the part of the heavens—near Theta Centauri—towards which the meteors were moving. Pogson did so, and saw in that part of the heavens two cloud-like objects moving along a course corresponding with that which attendants of Biela's comet would have followed as viewed from the earth. Now Mr. Hind, in discussing the question of the possible rediscovery of Biela's comet, takes as a probable assumption that the comet really touched the earth on November 27, 1872. "Intersecting, or at least passing very near to, the earth's orbit, on November 27," he says, "the comet must have been descending to a perihelion passage a month later, or about December 27·6; such at least would be the date when the meteoric shower would arrive at its least distance from the sun. In this fact appears the only ground upon which we can now work to obtain an idea of the probable position of the comet in the present year." Then, having given the most probable elements of the orbit of Biela's comet as determined from the observations of 1846 and 1852, he says that if the meteoric cloud of November 27, 1872, was moving in this orbit, "a revolution counted from December 27·6 in that year will bring us to about September 8, 1879, as the epoch of next perihelion passage. Assuming September 7·5, we should have the following sweeping-line for that date:—

Time from perihelion. Days.	Right ascension.	North declination.	Distance from earth.	Intensity of light.
0	140°·2	10°·8	1·66	0·47
−20	125·9	17·4	1·42	0·57

"It may, however," he proceeds, "be regarded as by no means improbable that the perihelion passage of the body which caused the shower of meteors may take place much later, and a very close and extended search will be required."

It should be noted, however, that the display of meteors seen on November 27, 1872, was by no means such as to suggest that the cloud of meteorites would be discernible as a nebulous object by reflected light. Again it seems certain that the two nebulous objects seen by Pogson, were not travelling as that meteoric cloud would have travelled; this was very clearly and satisfactorily shown early in 1873 by Captain Tupman. And if we suppose that either Pogson's nebulous clouds, or the meteoric flight, were Biela's comet, the delay of ten or twelve weeks is quite inexplicable by any possible perturbation, seeing that a cause effective enough to have made a difference of

ten or twelve weeks in the time of perihelion passage, would have entirely altered the character of the comet's orbit, whereas the only circumstance that enabled astronomers to identify the meteors of November 27, 1872, as attendants on Biela's comet and following in its track, was the observed agreement of their motions with those of bodies so travelling. On the whole, while it seems to us exceedingly probable that Andromeds or attendants on Biela's comet will be seen on the night of November 27, or perhaps a day or so earlier or later, we believe there is scarcely any, if any, chance whatever, of rediscovering the comet itself. The search ought to be made rather (we may now rather say, should have been made) where the comet should be seen, if not too completely dissipated, than where the meteoric flight, or either of Pogson's clouds, might be if really following in the track of the comet. We trust that small though the chance may be of obtaining fresh information respecting this remarkable comet, astronomers will watch carefully for the November Andromeds. As Hind says, "there is great justice in M. Otto Struve's remark: 'Kein Comet gebe mehr Ansicht über die Natur der Cometen im Allgemeinen etwas zu erfahren, als der Biela'sche.'"

Solar Parallax deduced from Observations of Mars.—Mr. Gill gives as the result of his observations of Mars, during the opposition of 1877 (it will be remembered that Mr. Gill visited Ascension Island to make these observations) a solar parallax of $8.''78 \pm 0.''015$, corresponding with a solar distance of about 93,093,000 miles. This distance is considerably greater than that which Professor Newcomb regards as the most probable mean (about 92,400,000 miles) of all the best observations. It agrees well with the distance resulting from the combination of Struve's constant of aberration with Cornu's determination of the velocity of light; but the constant of aberration can hardly be regarded as determined with a degree of accuracy sufficient to enable us to determine the real distance as accurately as by other methods, even if Cornu's determination of the velocity of light be considered trustworthy, within the necessary limits. On the whole, the result of Mr. Gill's observations will probably be regarded by most astronomers as disappointing, simply because it was hoped that it would serve to remove doubts as to the sun's true distance, instead of increasing them. But whether this is due to error in other estimates, or to the inferiority of the method used by Mr. Gill, is a point on which we should not care to express an opinion.

Tidal Theory of the Evolution of Satellites.—Mr. G. H. Darwin has suggested a theory of the evolution of satellites which is worth careful consideration. But it is vitiated so far as his treatment of the matter is concerned by an assumption the reverse of the truth. He remarks that if a planet were formed of fluid, it would assume a spheroidal shape under the influence of the planet's rotation, but if a satellite revolves in a circular orbit round the planet in the plane of the equator, tides will be raised in the planet, such that the spheroid will become distorted into an ellipsoid with three unequal axes, and the longer axis of the equator will always be directed towards the satellite. Thus the shape of the planet revolves along with the satellite, whilst each particle of fluid revolves with the planet, and has therefore to rise and fall twice in every revolution of the planet relatively to the satellite. Starting from this position, and taking into account the effects of friction,

Mr. Darwin arrives at the conclusion that the moon and earth originally formed part of the same body, and gradually separated into two; the present order of things having arisen from the tidal effects subsequently produced on each other by the two portions of what had once been a single mass. How far this theory would have to be modified if the dynamical theory of the tides be substituted for the statical theory thus made the basis of Mr. Darwin's reasoning, we have not yet ascertained. But it is certain that a rotating fluid mass, such as the planet is in the very beginning described to be, would not, apart from frictional effects, assume the form described by Mr. Darwin. On the contrary, the longer axis would lie in a direction at right angles to the line joining the centres of the planet and its satellite, for precisely the same reason that the orbit of the moon around the earth has its curvature increased at the quadratures and diminished at the syzygies. There is an excellent explanation of this, the true theory of tide in a frictionless ocean, in Sir Edmund Beckett's "Astronomy without Mathematics." Another was given by Sir George Airy in a paper read before the Astronomical Society, the substance of which (with the illustrations) will be found in the "Popular Science Review," vol. v. pp. 356, 357. The writer of the astronomical summary then described the explanation as "a very beautiful geometrical proof that, contrary to generally received notions, were the tides to move without friction, there would always be low water under the moon."

Babylonian Astronomy.—In the last four numbers of the "Notices of the Astronomical Society," there is an interesting paper (described as preliminary only) by Professor Sayce and Mr. Bosanquet, on ancient Babylonian Astronomy. We need not here consider the nature of the Babylonian calendar, because much space would be required duly to elucidate the subject. But there are some points relating to the identification of stars which may be noticed as apparently requiring further examination by the authors of the paper. It appears that the inscriptions are written in at least two languages —Assyrian and Accadian; and "everything has in consequence two names at least, though these are generally represented by the same character." This is an obvious source of difficulty. But still more likely to mislead is the circumstance that "the planets frequently assume the names of stars in whose neighbourhood they were observed." It will be manifest that extreme care must be taken in the investigation of Babylonian records of observations, under this perplexing system. Professor Sayce and Mr. Bosanquet consider only in their present paper a star called Icu or Dilgan, the former name being Assyrian, the latter Accadian, and signifying the "messenger of light." This star was used to determine the arrangement of lunar months in each year. Thus the following rule is given: "When on the first day of the month Nisan the star of stars (or Dilgan) and the moon are parallel, that year is normal" (or has twelve months); "When on the third day of the month Nisan the star of stars and the moon are parallel, that year is full" (or has thirteen months). This inscription is in Accadian, the most ancient language of the inscriptions. "It may be expected to belong to a time earlier than 2000 B.C." From this rule the authors of the paper deduce the conclusion that Dilgan, the "star of stars" or the "messenger of light," is Capella. Now Capella is a very fine star, but unless it has diminished wondrously in lustre in recent times, it could

scarcely have deserved to be called the "star of stars." It is also too far from the ecliptic to be used conveniently as a regulator of the calendar. On the other hand, we must not be misled by the name "messenger of light" to suppose Dilgan identical with Venus, whose orb has been called Phosphorus and Lucifer (each name signifying the "light-bringer"), for manifestly no planet could be used, as Dilgan was, to regulate a lunisolar calendar. We should be disposed to infer that the "star of stars" was the Pleiades, if evidence can be found for the use of the Accadian word for star to signify also a star-group (as *astrum*). We have every reason to believe that the Pleiades were used to measure the year, and from the position of this star group near the ecliptic it would be far better suited than Capella for the purpose indicated in the above-quoted rule.

Opposition of Mars.—Mr. N. E. Green, who did such good work in the observation of Mars at the last opposition, calls attention to the desirability of careful observations of the planet during October, November and December next. This will be the most favourable opportunity for many years for examining the details of the equatorial continents. "A careful search should be made for the remarkable dark canals figured by Professor Schiaparelli, which are represented by him as connected with the bays of the Sea of Maraldi and the Strait of Herschel, especially with the two points of Dawes's Forked Bay. The northern declination of Mars will compensate in great measure for the reduction in its diameter when compared with that of last opposition, and every use should be made of this occasion for the re-examination of previous drawings." The astronomers of the Washington Observatory point out that the satellites can hardly be seen, even with the most powerful telescopes, except for a few weeks before and after opposition. It is to be hoped that those capable of taking part in the search for these minute and most difficult of telescopic objects will spare no efforts to obtain exact and trustworthy observations, whereby the theory of the Martian satellites may be advanced as far as possible.

The Planets for the Next Quarter.—Saturn comes to opposition on October 5th, at 11 P.M.; Neptune on November 3rd, at 10 A.M.; and Mars on November 12th, at 8 P.M. On October 6th Mercury will be in superior conjunction with the sun; Venus at her greatest brilliancy as a morning star on October 31st.

Partial Eclipse of the Moon.—There will be a partial lunar eclipse, visible at Greenwich on the evening of December 28th; first and last contacts of the shadow will occur at 3h. 37m. and 5h. 15m. respectively. The magnitude of the eclipse, lunar diameter as 1, will be only 0·167.

BOTANY.

Fertilization of Red Sea-weeds by the Agency of Infusoria.—Professor Dodel-Port, of Zurich, has communicated to "Kosmos" an account of some exceedingly interesting observations made by him on the fertilization of a Floridean Alga, *Polysiphonia subulata*, T.Ag., which appears from his researches to present a singular combination of analogies with the anemophilous and entomophilous phanerogamous plants. An abstract of Professor

Dodel-Port's paper, with figures, appears in "Nature" of September 11. Like many other Florideæ, *Polysiphonia subulata* is dicœcious, and the male and female plants appear often to grow at a considerable distance apart. The antherozoids, which are produced from antheridia presenting a considerable external resemblance to microscopic ears of maize, are described as mere globules of protoplasm, containing a small highly refractive nodule and a few plasma granules, but entirely destitute of cell-wall, and consequently of the cilia, by means of which the antherozoids of so many Algæ make their way through the water in search of the female organs which they are destined to fertilize. The antherozoid is thus precisely analogous to the pollen grain of an anemophilous phanerogamous plant.

The female reproductive organ in this plant is a multicellular body forming an outgrowth from the apical parts of the branches of the thallus. The youngest of these carpogonia is found nearest the apex, those lower down being more mature. The structure of the carpogonium is described by Professor Dodel-Port in detail, but the most important point for our present purpose is the presence at its summit of two hair-like organs—a forked hair composed of several cells; and a trichogyne, a slender, colourless, unicellular hair, a little shorter than the forked hair, and produced from the surface of the carpogonium at a later period, making its appearance, in fact, about the time when the unfertilized carpogonium arrives at maturity. When full grown it is of a cylindrical form, abruptly rounded off at the extremity, and its narrow interior canal is filled with colourless, finely granular protoplasm. The trichogyne is most important, as it is the receptive organ, analogous to the elongated style which occurs in so many phanerogams. Fresh antherozoids of *Polysiphonia subulata* on coming into contact with the upper part of the trichogyne, which seems to some extent to act as a stigma, immediately adhere to it firmly, when the granular contents of the antherozoid pass into the interior of the trichogyne, and a part of them descending the canal in the latter reach the carpogonium, of which they fertilize the central cell. This process, as will be seen, is very analogous to that which takes place in phanerogamous plants.

In the case of anemophilous or wind-fertilized dicœcious plants it is well known that the chance of fertilization is usually greatly increased by the enormous quantity of pollen which the male flowers yield to every passing breeze, and a similar provision is found to prevail in the case of the dicœcious *Polysiphonia*. It is perfectly clear that the antherozoids of this plant, being quite destitute of any locomotive organs, must be passive in their further proceedings, and they are no doubt carried along in all directions by the currents, and other movements of the water, until, on meeting with the trichogyne of the female plant, they adhere to it, and fulfil their duty. When the two sexes grow at no very great distance apart, Professor Dodel-Port seems to think that the small marine animals, crustacea, annelids, star-fish, infusoria, &c., which swarm in the submarine forests of Florideæ, may aid importantly in effecting the transportation of the fertilizing element to the female organ, but in the course of his investigations, he discovered that certain minute animals interfere in the process in a much more curious and interesting fashion, vividly reminding us, indeed, in the singular adaptation of means to ends, of the wonderful relations unquestionably existing

between insects and flowering plants. On the growing thallus, and especially on the youngest branches, Dr. Dodel-Port, constantly found an immense number of the well-known Bell-Animalcules (*Vorticella*), which were, as usual with them, in incessant motion. These little creatures were found to feed upon the antherozoids floating about in the water; but, besides those which they manage to swallow, a considerable number are whirled about in the vortex caused by the cilia of the animalcule, which no doubt stops them in the course impressed upon them by larger submarine currents, and keeps them as it were hovering about the neighbourhood where their business lies. As the *Vorticellæ* are constantly changing their position by the contraction and extension of their little footstalks, the whirls set up by them in the water must become very complex, and the best proof that the action of these little vortices upon the antherozoids is beneficial to the plant, is to be found in the fact that it was through their agency that the author was enabled to observe the attachment of the antherozoids to the trichogyne. The presence of the *Vorticellæ*, in fact, imparts to the passive antherozoids a motion analogous to that with which the ciliated sperm-cells of other Algæ are endowed. In the case of this *Polysiphonia*, the beneficial action of the whirls produced by the *Vorticellæ* is supposed to be increased by the presence in the immediate vicinity of the trichogyne of the forked hair above-mentioned. This hair, it is believed, will divide the whirls, and thus produce subsidiary whirls, tending directly to bring the antherozoids into contact with the trichogyne. In his conclusion Dr. Dodel-Port has the following remarks:—"The total absence of active organs of locomotion in the antherozoids of Florideæ, points to a common ancestor from which the different branches of the Florideæ have inherited the immobility of the antherozoids. During the differentiation of the red seaweeds, many forms have no doubt died out in consequence of fertilization not taking place through the passivity of the male cells, while other forms have retired to localities which favour the process of fertilization by the active currents of the water, in spite of the immobility of the antherozoids. It is well known that we now find most of the existing species of Florideæ on the coasts of the warmer seas, which are constantly washed by the waves, while the northern coasts, which are covered with crusts of ice during a great portion of the year, are very poor in red seaweeds. Future researches will have to show how far in many of these aquatic plants the differentiation of the genera took place in the direction of an adaptation to the small marine animals which inhabit them, and favour their fertilization in the way I have pointed out."

CHEMISTRY.

Norwegium.—This name has been given by Dr. Tellef Dahll to a newly discovered metal occurring in the copper-nickel, and nickel glance of Oteroë, a small island near the town of Krageroë, Skjœrgaarden, in Norway. The mineral is roasted, the product dissolved in acid, and precipitated by sulphuretted hydrogen, and the well-washed precipitate, free from nickel, again roasted. The product thus obtained is the crude oxide of Norwegium.

It is next to be dissolved in aqua regia, and precipitated with the right amount of potash (in excess of the reagent the oxide redissolves), whereby an emerald green precipitate of Norwegium hydrate is obtained. This has now to be reduced with carbon or hydrogen. The metal is white, pretty malleable, of the hardness of copper, melts at a low red heat, has a density of 9·44, is soluble with difficulty in hydrochloric acid, but readily so in nitric acid; the solution is blue, and when diluted becomes green; the metal is also soluble in dilute sulphuric acid. The atomic weight appears to be, as a mean of two not very well according determinations, Ng = 145·95 if the oxide be regarded as NgO. As characteristic re-actions the following are given. The solutions of the metal are precipitated by potash, ammonia and sodium carbonate; the precipitates are green, and re-dissolve in an excess of the reagent, forming a blue solution. Sulphuretted hydrogen gives even in very dilute solutions a brown precipitate insoluble in ammonia sulphide. Before the blowpipe in the oxidizing flame in the borax bead, it gives a yellowish green colour which cools to a blue glass; in the reducing flame the blue colour is brighter; in a bead of phosphorus salt it shows a yellowish green which on cooling turns first an emerald green, then violet, and then to a blue glass. The oxide is easily reduced with soda on charcoal.—(*Compt. rend.* 1879, ii. xxxix. 47.)

Uralium, a New Metal of the Platinum Group.—As far back as 1869, A. Guyard discovered this metal in commercial platinum obtained from Russian ores. Next to silver it is the whitest metal known. Its malleability is as great as that of the purest platinum, but its ductility is much greater, and it is almost as soft as lead. Its melting point lies near that of platinum, and it is not volatile. Its specific gravity is 20·25, and its molecular volume, like those of osmium, platinum, and palladium, is 6·25. Its atomic weight has been found to be 187·25. In its chemical properties it is difficult to distinguish from platinum.—(*Monit. Sc. Quesneville*, July, 1879.)

Scandium, a New Earthy Metal.—L. F. Nilson announces the discovery of a new metal to which he has given the name of scandium. (*Ber. deut. chem. Gesellschaft*, 1879, No. 6.) It has been separated from ytterbia, but has not yet been obtained in a state of purity: it is the oxide in a white earth, which gives no absorption bands. After ignition it is attacked but slowly by dilute nitric acid, but more readily by hydrochloric acid. The solution of the nitrate is completely precipitated by oxalic acid. The nitrate is completely decomposed at a temperature at which ytterbium nitrate is only partially resolved into a basic salt. The atomic weight, calculated on ScO, must be below 90. The author doubts, however, this composition of the oxide, and thinks the formula ScO_2 more likely to be the correct one. Scandium would then rank between tin and thorium, and with an atomic weight of about 170 would occupy the vacancy intervening between 118 and 234.

"*Allotropic Copper.*"—Wiedemann has sought to refer the peculiar comportment of copper obtained by electrolysis from solution of its acetate, to its containing a considerable quantity of copper oxide. Schützenberger, who described it, adhering to his original view, states that the metallic deposit first obtained does contain much oxide, but in that which is afterwards obtained he found less than 5 per cent. of the oxide. His "Allotropic

Copper" thus formed, is not a blackish-brown mass such as Wiedemann obtained, but is bright, lustrous, and bronze-coloured; it oxidizes very quickly in the air, acquiring a beautiful indigo-blue lustre; when treated with dilute nitric acid, it evolves nitric oxide only; its density is considerably less than that of an equal amount of a mixture of copper and oxygen. Finally it changes, without loss of weight, into ordinary copper, if preserved without access of air, and the change takes place rapidly at 100°.—(*Bull. Soc. Chim. Paris*, 1879, xxxi. 291.)

The Gray Modification of Tin.—A window in the church of Freiberg, which had long been built up, was recently opened, when a wooden box was found in a good state of preservation, and enclosing a medal and a number of rings. The box may have lain in the niche three or four hundred years. The shaking which it underwent during removal from the niche sufficed to break the medals and the rings into a great number of pieces, some of which came into the possession of Arnulf Schertel, who has published the results of an examination of them.—(*Jour. prakt. Chem.*, 1879, xix. 322.)

The rings, which are 15 mm. in diameter, and 2 mm. in thickness of metal, are, like the medal, cast. The colour is a reddish blue-gray, the fracture uneven, but in the case of some fragments distinctly columnar. The metal is tin of great purity, free from lead, and containing a trace only of iron and sulphur. It is so fragile that it can be broken between the finger nails. By merely pouring hot water on the fragments they acquire a brighter colour, and a very considerably greater cohesion. Strong pressure, or a severe blow brings out a whiter colour. This tin has undergone the molecular change observed by O. L. Erdmann in organ pipes, composed of tin containing some lead, and by J. Fritzsche of St. Petersburg, in blocks of Banca tin. The determinations of the specific gravity of the metal made with great care gives the numbers 5·809, 5·781, and 5·803; fragments were next placed in hot water, and left there for some time until they acquired a bright colour. The specific gravities then determined were found to be 7·280 and 7·304. The gray modification increases in density by treatment with hot water, and acquires that of melted tin. Specimens of the gray tin described by Fritzsche were found to leave a density of 6·020, 6·002, and 8·930, but after treatment with boiling water it rose to 7·24 to 7·27. A specimen of the St. Petersburg gray tin was exposed in a glass vessel to the temperature of boiling ether, 35°, for one hour and a half, at the end of which time it had acquired a white hue, and the density of 7·23. A quantity of the Freiberg gray tin was exposed in the same way for three hours; its density remained 5·77, and its colour showed no change. When acetone was employed in place of ether, and the temperature thereby raised to 50°, the brighter hue was at once remarked, and after exposure for a short time to a temperature of 59°, its specific gravity rose to 7·279. To test the difference in chemical action of the gray and white modifications of tin, the following experiment was made. Two large fragments of rings were taken, and a platinum wire attached to each piece. One was converted into white tin, by immersion in boiling water, and then both were attached by means of platinum wires to a galvanometer. The gray variety was electronegative towards the white variety when dipped in dilute potash solution, in hydrochloric acid, or sulphuric acid; electropositive in dilute sulphuric acid.

The gray tin, therefore, is somewhat passive. It is a curious fact that among the gray rings contained in the wooden box were five rings having the colour and characters of ordinary tin.

The Source of the Hippuric Acid in the Urine of Herbivorous Animals.—A number of chemists have taken up this question with little effect. Hallwachs sought in vain for benzoic acid in hay, and found no substance in any way related to it. It is pointed out by Loew (*Jour. prakt. Chem.*, 1879, xix. 309), that Hallwachs did not search for kinic acid, and that Lautemann has long since suggested that this substance may be present in hay, as it is pretty plentiful in the vegetable kingdom. This Loew now finds to be the case. If hay be moistened with cold water and allowed to stand for 24 hours, and the contents be precipitated with lead acetate, and the well-washed precipitate be treated with sulphuretted hydrogen, a liquid is obtained which has now to be treated with milk of lime in excess to remove the phosphoric acid. The concentrated filtrate is then made hot, and while so, mixed with hot alcohol whereby the lime kinate is separated as a viscous mass. Further treatment consists in throwing down the lime with oxalic acid, and again adding alcohol to the concentrated liquid, whereupon the acid separates slowly in small granular crystals. Six grammes of kinate were obtained from one kilogramme of hay. When distilled with manganese peroxide and sulphuric acid it evolved kinone. The kinates are very soluble in water, and readily precipitated by dilute alcohol.

Action of Hydrogen on Carbonic Oxide in the Presence of a Red-Hot Platinum Wire.—J. Coquillion has found when moist carbonic oxide is passed over a red-hot platinum wire many times backwards and forwards, a change of volume is noticed which, when the gas was shaken with potash, disappeared, to appear again, however, as soon as the operation was renewed, until finally nothing is left but nearly pure hydrogen. The change noticed must take place in accordance with the equation—

$$CO + H_2O = CO_2 + H_2.$$

The presence of nitrogen does not interfere with the change. The conversion of carbonic oxide into carbonic acid, during the decomposition of water vapour, cannot take place all at once, for between the CO, CO_2, H and H_2O, a state of equilibrium is set up, which limits the action. A moist mixture of 31·50 volume per cent. of carbonic oxide, 8·08 per cent. of hydrogen, and 60·42 per cent. of nitrogen, increased in volume 10 per cent., and was changed into 21·3 per cent. of carbonic oxide, 10·00 per cent. of carbonic acid, 18·08 per cent. of hydrogen, and 60·62 per cent. of nitrogen. Pure carbonic oxide increased 30 per cent. in volume, and the mixture consisted of carbonic acid 30 per cent., hydrogen 30 per cent., and carbonic oxide 70 per cent. The author made these experiments during some investigations of the gas found in Siemens's generative furnaces. They were fed with coke, and it was not possible to convert the whole carbonic acid into carbonic oxide, however high the layer of ignited coke be made. The vapour of water contained in the latter takes part in the reaction by reoxidizing the carbonic oxide. The greater its quantity the higher rose the percentage of carbonic acid and of hydrogen. This reaction takes place in smelting furnaces. Ebelmen held that hydrogen acted directly as coke,

while it is evident from the above that it is in reality carbonic oxide which enters into the reaction.—(*Compt. rend.*, 1879. lxxxviii. 1204.)

Reduction of Potassium Perchlorate.—Tommasi finds that this substance is not reduced by zinc, cadmium, magnesium, or aluminium, either in acid or in alkaline solution, at ordinary temperature or at 100°. Moreover it is not acted upon by sodium amalgam, nor reduced by ferrous hydrate. When the acetate of lead or copper is reduced by these metals, this salt, if present, undergoes no change. The perchlorate is, however, converted into chloride readily and at moderate temperatures, if mixed with sodium bisulphite, and acted upon with rods of zinc. The hydrosulphite produced by this reaction is converted into sulphite at the expense of the oxygen of the perchlorate, in accordance with the following reaction—

$$4SHNaO_2 + ClKO_4 = ClK + 4SHNaO_3.$$

No hydrogen is evolved. Towards the end of the reaction hyposulphite is also found—

$$2SHNaO_2 = H_2O + SNa_2O_3S.$$

—(*Ber. deut. chem. Gesell.*, 1879, xii. 1701.)

The Direct Combination of Cyanogen and Hydrogen.—Gay-Lussac was unable to cause these substances to unite directly, either by the application of heat, or by the electric spark. In his day the influence of time on certain chemical reactions had not been studied. Berthelot therefore has repeated the experiment. It is now many years since the author showed that in a mixture of cyanogen and hydrogen, through which electric sparks had been passed, acetylene and hydrocyanic acid were formed. It cannot be clearly seen from this whether the substances directly unite, or whether acetylene be not first formed, and nitrogen separated, and hydrocyanic acid is not subsequently produced. A quantity of dry cyanogen and hydrogen in equal volumes were passed through a tube heated to 500°–550°, and a partial combination was at once noticed. The escaping gas contained 47 to 48 per cent., instead of 50 per cent., of free hydrogen. In closed tubes this reaction took place more readily. After they had been heated for several hours, and were opened over mercury, a contraction of volume amounting to one-seventh was reached, due probably to the formation of paracyanogen. Potash quickly absorbed five-sevenths, and the remaining seventh consisted of nearly pure hydrogen. The reaction, therefore, had taken place in accordance with the equation: Cy + H = HCy. The process is quite analogous to that by which hydrochloric acid is produced, with the difference that it takes place more slowly, and at a higher temperature. At lower temperatures it goes more slowly; at higher, nitrogen is set free. Zinc, cadmium, and iron, heated with cyanogen in tubes to 300°, formed cyanides of those metals, and no cyanogen was decomposed. Zinc, even at ordinary temperatures, is acted upon by cyanogen after several days exposure to it; at 100°, after the lapse of some hours, an absorption of the gas is remarked. Cadmium is passive in the cold, and at 100° only traces of cyanogen are absorbed. Iron is passive at 100°; silver and mercury are passive at all temperatures. The synthetic formation of hydrocyanic acid, whether by the combination of cyanogen and hydrogen in equal volumes without condensa-

tion, or by the combination of acetylene with nitrogen, also in equal volumes without condensation,

$$C_2N + H = C_2NH\,;\ C_2H + N = C_2HN,$$

points to a striking relation between these two bodies, regarded as compound radicals.—(*Compt. rend.*, 1879, lxxxix. 63.)

GEOLOGY AND PALÆONTOLOGY.

American Jurassic Mammals.—Professor O. C. Marsh has discovered some interesting remains of small mammals of Jurassic age, in the so-called "Atlantosaurus beds" of the Rocky Mountains. All the specimens are lower jaws, as is general in our own Stonesfield and Purbeck deposits, and they have enabled their discoverer to distinguish four species. Two of these he regards as Marsupials, but as belonging to a peculiar genus, *Dryolestes*. One specimen possesses the strongly inflected angle characteristic of marsupial mammals; another shows that the number of premolar teeth was at least four, showing that the genus is quite distinct from *Didelphys*. Professor Marsh names the species, both of which were of small size, *Dryolestes priscus* and *D. vorax*. A third species is represented by the left side of a jaw, the two extremities of which are either wanting or badly preserved. It is remarkable for the great number of molar and premolar teeth, which are apparently at least twelve in number, and possibly more. Some of the premolars have two fangs; all the molars are single-fanged; the former have compressed and recurved, and the latter conical crowns. A large pointed tooth lying near the jaw is regarded as probably a canine. The animal, which was somewhat smaller than a weasel, and probably insectivorous in habits, presents close resemblances to the genus *Stylodon* of Owen, from the English Purbecks, with which Professor Marsh thinks it may constitute a distinct family, Stylodontidæ. He names it *Stylacodon gracilis*, the specific name being in allusion to the slenderness of the jaw. A fourth form is said to resemble in some respects the genus *Triconodon* of Owen, the molar teeth having each three pointed cones; but there are four such teeth instead of three, and the middle cone in each tooth is larger than the others. The angle of the jaw is much produced but not inflected; the author nevertheless regards the little animal as having been probably an insectivorous Marsupial, allied to *Triconodon* and *Phascolotherium*. He names it *Tinodon bellus*, and suggests that the uninflected angle of the jaw, and the position of the coronoid process, which ascends at right angles to the ramus immediately behind the last molar, would indicate that it forms the type of a new family (Tinodontidæ), if not that it may have been a placental mammal. —(*Silliman's Journal*, July and September, 1879.)

Pélé's Hair.—Professor Dana publishes some notes on the curious fibrous product of the crater of Kilauea, commonly known by the above name, founded on a supposition of the natives that it was the hair of their goddess Pélé. Professor Dana gives two new analyses of this substance, which are very nearly accordant. Their mean shows a composition almost precisely that of ordinary dolerite, as shown in the following comparative statements:—

	Pélé's Hair	West Rock "Trap"
SiO^2	50·75	51·80
AlO^2	16·54	14·21
FeO^2	2·10	3·55
FeO	7·88	8·26
MnO	trace	0·42
MgO	7·65	7·63
CaO	11·96	10·68
Na^2O	2·13	2·15
K^2O	0·56	0.39
ign.	0·35	0·63
Total . .	99·92	99·72 + PO^5 0 14.

This "trap" consists of labradorite and augite, with some magnetite, and the perfect fusibility of such a compound is well indicated by the facts observed at Kilauea. There is hence no question as to the complete fusion of such ingredients in a volcano, even where no moisture is present. "The analyses," says Professor Dana, "add another to the many examples already known, proving that there was no difference in constitution between a large part of the material in fusion rejected in mesozoic time, and that thrown out by modern volcanoes; and it illustrates the fact that geology has no good basis for the distinction of 'older' and 'younger' among igneous rocks."

According to C. F. W. Krukenberg, the fibres of Pélé's hair are often tubular, and sometimes bent and formed into loops; they frequently contain air-bubbles, and occasionally microlites. They are usually enlarged where they contain crystals (or microlites), and also about many of the air-cavities.—(*Silliman's Journal*, August, 1879.)

Palæozoic Plants.—Count Gaston de Saporta notices certain organisms of Lower Silurian age, the nature of which has hitherto been very doubtful, as they have been regarded by different observers sometimes as vegetable impressions, sometimes as casts of the tracks of annelides or other animals. Three types are especially referred to by M. de Saporta, namely, *Tigillites*, *Bilobites* or *Cruziana*, and the Scandinavian *Eophyton*. *Tigillites* are regarded by him as representing the tubes of arenicolous annelides. They are cylindrical bodies associated in colonies, placed vertically in the rocks, and filled in after the death of the inhabitant. In appearance and dimensions, in the presence of obscure zones of growth still visible on the surface, in the mode in which they terminate below, and, in fact, in all their characters, they resemble the *Spirographis* now living on the shores of the Mediterranean.

Bilobites or *Cruziana* is regarded as a marine vegetable organism, although nothing analogous to it exists among the Algæ of the present day. M. de Saporta adduces, in support of the vegetable nature of these fossils, a peculiarity in their mode of fossilization. They are found in half-relief upon the lower surface of the beds in which they are preserved, and are always represented by a hollow impression on the upper surface of the subjacent beds. This half-relief, showing all the details of the external organization of the ancient plants, is the result of the imbedding of a fleshy or cartilaginous body which, after moulding itself in the sediment, has disappeared by de-

composition. The pressure of the beds in course of formation would then fill up the lower half of the mould, forming the cast in relief. The *Cruzianæ* consist essentially of two convex parts united in the middle line, and marked on the surface with oblique sinuous striæ. Their extent renders it impossible to trace their whole length, or to obtain an entire individual with the superior termination of the frond. Nevertheless, from a number of remarkable impressions collected by Professor Morière of Caen, we see that the lines of junction, which are at first simple, afterwards become complicated by ramification, and produce at the summit a goffered, sinuous expansion. At many points on the surface of the phylloma of *Cruzianæ* scars of insertion are observed, which seem to be produced by radicles or organs of fructification, leaving, when shed, the traces of their attachment.

The *Eophyta* are cylindrical bodies (stems or phyllomata). They are more or less elongated, perhaps ramified above, or dilated and laterally compressed, and always marked with regular striæ and fine channels running longitudinally, and often resembling nervures. They have no resemblance to the *Cruzianæ*, and the two types must have constituted distinct genera, if not families. Neither of them can be regarded as nearly related to any existing *Algæ*, but they may be regarded as extinct types very distantly allied to the Caulerpeæ.—(*Assoc. Franç. pour l'Avancem. des Sciences*, Séance de 1878, p. 576.)

Volcanic Products at the bottom of the Pacific.—The Abbé Renard, and Mr. J. Murray communicated to the Geological Section of the British Association, at Sheffield, the results of an examination of the materials brought up by the *Challenger's* instruments from the bottom of the central Pacific. The area from which the materials submitted to the Abbé Renard were derived, extends from the Sandwich islands to 30° S. lat., having the Low Archipelago approximately in its centre. Volcanic matter was found to play an important part in the formation of the bottom, being present in the form of lapilli and ashes distributed in great abundance in the "red clay," of which we have heard so much. The lapilli nearly all belong to the basaltic type, passing from felspathic basalt to allied rocks, in which the vitreous base acquires greater and greater development, until it almost entirely displaces the crystalline constituents of the basalt, when the fragments become mere glassy rocks of the basic series, generally containing some crystals of peridote, innumerable crystallites, the latter sometimes grouped in opaque granules, sometimes arranged regularly around the peridote microlites. From the forms of these volcanic fragments, which are often coated with manganese, their association with volcanic ash, and their lithological constitution, they cannot be derived from submarine flows of lava. They are rather incoherent volcanic products, or lapilli, the accumulations of which in the Pacific form a series of submarine tuffs.

One of the most remarkable facts, brought to light by these soundings in the Pacific, is the large share taken in the formation of these sedimentary deposits by palagonites, perfectly identical in lithological characters with those of Sicily, Iceland, and the Galapagos islands. Many are in fact glasses of the basic series, either consisting of sideromelane, or decomposed into a red resinoid substance. The small lapilli of two or three inches in diameter are cemented by zeolites, showing the crystalline forms of christianite.

The presence of these readily alterable basic glasses at once reveals the source of the clayey matter with which they are associated, as wherever rocks of this type occur, their decomposition into clay is observable.

Among the minerals present in the volcanic ash are rhombic tabular crystals of plagioclase, augite, magnetite, and a little sanidine or hornblende. It is singular that quartz-grains are practically absent, in striking contrast to coast deposits. This fact, however, is not so unexpected as the formation of zeolites in the free state. Minute fibrous radiated spherules are formed in the mud, possessing the crystallographic characters of christianite. Besides these zeolitic spherules, other crystals of the same kind occur in the form of minute prisms, and in such prodigious numbers that they make up about one third of the red clay. These and the zeolitic spherules are regarded by the authors as belonging to one mineral species, and they remark that the formation of these, and of the red clay in which they are developed, is easily understood if we bear in mind the lithological nature of the basic tuffs, and of their products of decomposition.—(*Nature*, September 18, 1879.)

Mud-Volcanoes.—Professor Gümbel of Munich has communicated to the Bavarian Academy (*Sitzungber.* 1879), a paper on mud-volcanoes and their products, his examination of which leads him to the following results. The mass of mud erupted is nothing but softened argillaceous, or sandy-argillaceous, stratified rock, derived from the immediate vicinity, and probably brought up from no great depth. It often contains organic remains, whilst true volcanic products (such as ashes, lapilli, lava, and pumice), take no part in its formation. It is only exceptional, if in the midst of volcanic formations the latter, softened superficially like the stratified rocks by gas and water, furnish the eruptive material, and indeed no such case is yet known with certainty.

Besides the abundant outflow of water, the efflux of gases at high pressure is necessarily and genetically connected with mud-volcanoes. Among these, carburetted hydrogen holds the first place. The high tension of the gases which flow out, and the long duration of the phenomena, do not infer the existence of a great accumulation low down in the earth, because upon such a supposition the provision must be exhausted in a comparatively short time. The persistent formation especially of the carburetted hydrogen, the principal of these eruptive gases, necessarily presupposes the presence of organic constituents in the deeper seated stratified rocks, and this is also confirmed by the regular occurrence of petroleum, naphtha, asphalte, or bituminous materials in connection with mud-volcanoes. It is not improbable that phosphuretted hydrogen is also produced during this process of decomposition, and the presence of this gas would furnish a satisfactory explanation of the frequent spontaneous ignition of the outflowing gases. On the other hand, the more abundant occurrence of carbonic acid would seem to indicate a certain approach to volcanic processes.

The intermixture of soluble salts, especially chloride of sodium, in the mass of mud, may be explained in part by the circumstance that many mud-volcanoes are situated in the vicinity of the sea, or upon a soil soaked with sea water. In favour of this, we have the presence of iodine and bromine in the mass of salts produced. It may also be assumed that the strata contiguous to the channel of eruption may contain abundantly such

salts as gypsum and rock salt, from which the outflowing water extracts its saline contents. Or the saline constituents may be dissolved from other strata by the water before reaching the mud-volcanoes, and left behind in the dry mud, upon the evaporation of the water.

The mode of distribution of mud-volcanoes shows a certain general relation to volcanic regions, and volcanic eruptions. They are, however, found in countries at present unaffected by volcanic phenomena, but in this case they either occur in districts which are frequently disturbed by upheavals and sinkings, or are confined to tracts of great geotectonic fissures and lines of displacement, which traverse the crust of the earth, and lead down to great depths.

From all these facts Professor Gümbel thinks it follows that the true focus of the phenomena connected with by far the greater number of mud-volcanoes cannot be directly identified with that of the volcanic activity of the depths of the earth, but that these phenomena are due rather to the presence of certain stratified rocks, and to their containing intermixtures capable of furnishing bituminous substances. In isolated cases it may be that gases connected with volcanic processes produce phenomena similar to those of ordinary mud-volcanoes, or associate themselves with the carburetted hydrogen gases of the true mud-volcanoes, just as, *vice versâ*, the latter gases frequently appear among volcanic exhalations. The stratified rocks involved in the process, must be situated deep in the earth's crust, where the conditions (warmth, &c.) necessary for the evolution of the gases and bituminous materials from the organic intermixtures are present, and at the same time the crust of the earth is traversed by fissures deep enough to enable the volatile materials thus formed under pressure to make their way to the surface. Such favourable conditions will occur most frequently where the younger sedimentary formations are deeply buried, and traversed by deep fissures by volcanic action. In this way we see how the phenomena of mud-volcanoes are distantly connected with true volcanic activity. In other cases, volcanic action may as, it were, have carried the conditions of formation of the eruptive gases and bituminous substances nearer to the surface, and into the higher beds of the sedimentary rock. Such a relation between mud-volcanoes and vulcanicity may be assumed especially in Sicily. Nevertheless, the phenomena of the so-called mud-volcanoes are so fundamentally distinct from those of true vulcanicity, that it seems desirable to get rid of the connection, apparently implied by the name, by the employment of a new term, such as "mud-springs" (*Schlammsprudel*).

Palæocoryne. Mr. G. R. Vine read a communication before the Geological Section of the British Association, in which, after referring to the great abundance of Carboniferous Polyzoa which have been discovered of late years, he gave the results of his researches upon the curious fossil bodies described by Professor Duncan and Mr. Jenkins, as probably fossil Hydroids, under the name of *Palæocoryne*. These supposed Hydroids have been regarded by some palæontologists, and notably by Dr. and Mr. Young of Glasgow, as mere appendages of Polyzoa. The author stated that he had identified all the species and forms of *Palæocoryne* that had been figured by Dr. Duncan in his various papers; but the conclusion he had arrived at was that these so-called organisms were neither hydroid, as was supposed by

Dr. Duncan, nor foraminiferal, as was suggested by Dr. Allman, but in all forms were referable to species of *Fenestella* and *Polypora*. Although this opinion was given with some confidence, the author was not prepared to say, at present, that the whole of Dr. Duncan's views were illusive. There could be no doubt but that the forms *P. scotica* were really infertile processes; but *P. radiata* had presented so many peculiar details to the author, that until he had satisfied himself as to the nature and purpose of this structure in the polyzoary of the Polyzoa, he was not in a position to prove that Dr. Duncan had given an erroneous judgment, although *P. radiata* might turn out to be, after all, a portion of *Fenestella* and not a parasite.

METEOROLOGY.

Rain and Temperature.—Mr. H. C. Fox, of Stoke Newington, read a paper before the British Association, at Sheffield, on the *Synchronism of mean temperature and rainfall in the climate of London*. The paper was accompanied by tables exhibiting each month and season for the past sixty-seven years, arranged in the order of its rainfall, and also in the order of its temperature, for the Royal Observatory.

The principal conclusions were stated to be:—

(1.) In each of the four months, from November to February, extreme cold tends to be synchronous with dryness, warmth with large rainfall.

(2.) In the summer months, from June to August, cold tends to be accompanied by much rain, warmth by dryness.

(3.) To put this in popular language, *rain brings warmth in winter and cold in summer*; that is (if rain be the cause, which is by no means proven), it mitigates the special character of each extreme season, winter and summer.

(4.) Very wet years tend to be either cold or warm, whilst years of drought tend to assume an average temperature.

MINERALOGY.

Mallardite and Luckite.—The name Mallardite has been given by A. Carnot to a new native manganese sulphate, and Luckite to a new native iron sulphate, which occur in the silver mine of Lucky Boy, at Utah (*Compt. rend.* 1879, lxxxviii. 1268). The former consists of small crystalline parallel fibrous masses, which are originally colourless and translucent, but on exposure to the air soon become white, and opaque, and weathered. It is easily soluble in water, and has the composition, $MnSO_4 + 7\,H_2O$. The sulphates already known are szmikite with one equivalent of water, fauserite with magnesia sulphate, and apjohnite with aluminium sulphate. The above may therefore be regarded as a new species. It is named Mallardite to honour M. Mallard of the *École des Mines*. The iron sulphate forms bright

bluish channelled prisms, and has the formula $(Fe,Mn)SO_4 + 7H_2O$, where the Mn is = about $\frac{1}{10}$ Fe. The mineral therefore stands between mallardite and melanterite. It weathers, but not in the air like the one, nor becomes of an ochre colour like the other. The crystalline form appears to be clino-rhombic. It derives its name from the place where it is found.

On the Behaviour of Silicates containing Fluorine, especially the Topaz and the Micas, at High Temperature.—Rammalsberg has instituted a number of experiments expressedly with the view of determining the form in which fluorine is contained in the minerals in question, topaz and the micas. He finds that at the high temperature of the porcelain furnace, from topaz only could all the fluorine be removed under favourable circumstances. His experiments pointed to the probability that a part of the fluorine passes off in the free state; in other words, that in the presence of water vapour hydrogen fluoride was formed, while the elements united to the fluorine potassium, lithium, magnesium, iron, aluminium, silicium, remain as oxides, while another portion of the fluorine passes off in the form of a silico-fluoride. This does not support the earlier view that silicium fluoride alone is evolved, and supports the theory of the author that fluorine is contained in these silicates in the same way as oxygen is. It appears, moreover, that, as a secondary action of the hydrogen fluoride, not only the fluorine present in the topaz in the form of aluminium silico-fluoride, but a certain amount of silicium of the oxysilicate, is converted into $SiFl_4$ and evaporates.—(*Wiedem. Ann.*, vii. 146.)

New American and Australian Minerals.—Under the name of Randite G. A. König, of Philadelphia, describes a new mineral, occurring on the granite in the neighbourhood of Philadelphia, in crusts, of a canary yellow to a citron yellow hue, which are transparent and apparently crystalline. It has a hardness of 2·3, and when heated in a closed tube evolves water, and acquires an orange red colour. Before being heated it is soluble in cold acid; after having been heated, it dissolves completely in hot acid only. 0·047 gramme of material collected for analysis had the composition:—

Lime	32·50
Uranium oxide	31·63
Water	6·53
Carbonic acid	[29·34]
	100·00

The formula derived from this, $Ca_5U_2C_6O_{20} + 3H_2O$, points to a relation existing between this mineral and liebigite. Before it can be determined whether a new species is actually present, it must be submitted to a more complete analysis. The name is chosen to honour Mr. Theod. Rand, of Philadelphia.—*Stibianite* is, according to E. Goldsmith, a new mineral from Victoria in Australia. It is massive, porous, has a reddish yellow colour, and a pale yellow streak, is dull, has a hardness of 5, and density of 3·67. An analysis made by W. H. Dougherty shows it to consist of—

Antimonic acid	81·21
Water	4.46
Insoluble portion.	13·25
	99·22

which points to the formula Sb_2O_5, H_2O. So incomplete an analysis hardly justifies the giving a new name to the substance.—*Huntilith* is a new mineral, of which two varieties have been found. One is massive, has a dark slate gray or black colour, is dull, amorphous, porous, and friable; the other is apparently crystalline, shows a cleavage, a bright slate colour, and occurs in calc-spar, is half malleable, has a hardness of $2\frac{1}{2}$. The density of the two varieties at 0° after impurities had been removed is, of the amorphous 7·47, for the crystalline 6·27. The chemical composition of the two sorts were found to be—

	I. Amorphous Variety.	II. Crystalline Variety.
Arsenic	21·10	23·99
Antimony	3·33	4·25
Sulphur	0·78	1·81
Mercury	1·04	1·11
Silver	59·00	44·67
Cobalt	3·92	7·33
Nickel	1·96	2·11
Iron	3·06	8·53
Zinc	2·42	3·05
Water	0·19	0·33
Gangue (silicate)	0·88	0·55
Do. (calcite)	2·35	1·10
	100·03	98·83

If the mercury be present as amalgam, Ag_2Hg, and the sulphur as pyrites as is most probably the case, and the Co, Ni, M, and the remaining Fe be reckoned with the Ag, making $R'' = 2R'$, we have in

I. R' : As + Sb as 319 : 110 or as 2·90 : 1.
II. R' : As + Sb as 332·5 : 110 or as 2·99 : 1.

Hence the mineral has the formula, Ag_3As, and may be regarded as an arsenic dyscrasite or a silver domeykite. This huntilith is found in large quantities in the Silver Islet Mine of Lake Superior, and is named to honour Dr. Sterry Hunt.—(*Zeitschrift für Kryst. und Mineralogie*, 1879, iii. 596–600.)

Swedish Minerals.—Blomstrand in a recent letter to the *Ber. deut. chem. Gesellschaft*, 1879, xii., 1723, communicates a few notes on recent researches on Swedish mineralogy. Hjalmar Sjögren describes native bismuth, associated with galena and pyrites, from Norberg's mine in Wermland. Bjelkite is the name given to a mineral species having the formula $2PbS,Bi_2S_3$. The older analyses of this mineral by Lundström have led him to adopt the formula $(FeS, 2PbS)_3\ Bi_2S_3$. A new bismuth sulpho-salt, *galenobismutite*, has the formula, PbS,Bi_2S_3, and occurs in compact, tin-white particles. Anton Sjögren has published a paper on the occurrence of manganese compounds in the Nordmarks mine in Wermland. It treats of the very interesting gangue-like formation, distinguished for the manganese compounds which it contains, met with first in Langbans mine, and now hit upon in Nordmarks since. The ground mass is manganesiferous calcspar, which contains manganosite (the formula being MnO) in well-developed

microscopic crystals in the same form, belonging to the regular system, as the periclase of Vesuvius, pyrochroite (MnO,H_2O), also crystallized, hausmannite, manganese spar, brusite, heavy spar, as well as hornblende and granite. T. Nordström publishes an analysis of vanadinite, now for the first time found in Sweden from the Undenäs (manganese) mine in West Gothland, and a mineral containing 5 per cent. of selenium from Fahlun. Selenium has been found in the sulphuric acid mud of Fahlun; but minerals containing this substance are very rare. G. Lindström describes *Thaumasite*, a new mineral species from Äreskutan in Jemtland, which has the following curious composition—

$$CaO,SiO_2 + CaO,CO_2 + CaO,SO_3 + 14H_2O.$$

Great Meteorite in Iowa.—Professor Peckham, in a letter to the editor of "Silliman's Journal" (July, 1879, p. 77), gives an account of the fall of a meteorite at 5 P.M., on May 10, at Estermills, Emmet County, Iowa. One fragment, weighing almost 500 pounds, fell on railroad land and buried itself 14 feet in stiff clay soil. Another portion, of about 170 pounds, fell on a farm at a distance of about two miles from the above. Smaller pieces, from a few ounces to several pounds in weight, were scattered in the vicinity. The fall was accompanied by a noise described as a continuous roll of thunder, associated with a crackling sound. The smaller fragment above mentioned is of an irregularly quadrate form, measuring about 15 × 18 inches, and 6 inches thick on an average. The metallic portion consists of an alloy of iron, nickel, and tin. A small piece of the metal polished and etched showed the Widmanstättian figures very finely. Half the mass is stony matter, consisting of dark green crystalline masses, imbedded in a light grey matrix. When the whole is powdered, a violent reaction ensues on the addition of hydrochloric acid, and this is increased by boiling, when all but the grey matrix is dissolved. Under the microscope in thin sections, olivine and a triclinic felspar appear to be imbedded in a matrix of pyroxene.

PHYSICS.

Absorption of Ultra-Violet Radiations by the Atmosphere.—M. Cornu read a paper on this subject before the Academy of Sciences in June. He showed that the probability of the solar spectrum extending beyond what can now be seen, is evidenced by its abrupt and sudden termination in photographs of the most refrangible end, as compared with the spectrum of iron vapour. He demonstrated the atmospheric absorption by introducing a tube 4 metres long, closed at the ends with fluor spar, between the collimator and prism. When the tube was full of air, line 32 of the Aluminium spectrum is not visible, but as a vacuum is produced, the line appears.

The Friction of Fluids.—Professor Unwin, of Cooper's Hill College, recently read a paper on this subject before the Physical Society. He premised that it had long been known that a board, dragged through water, suffers a resistance varying in some way as the square of the velocity; that a stream

moves uniformly at such a speed that the component of water-weight down the inclined bed is balanced by frictional drag on the bottom. The fluid in the neighbourhood of the stream is known not to move as a solid mass, the centre moving faster than the sides, and the different fluid layers rubbing against one another. The adhesion of the fluid to the solid against which it moves, also gives rise to sliding or rubbing action. It is desirable to have a set of experiments in which the conditions can be varied more than can be done by such methods. He thought it instructive to try a limited mass of water, and a virtually unlimited surface, such as is given by a disk in rotation. This apparatus he had constructed. Within the outer vessel is placed a thin copper chamber, the diameter of which is unalterable, but the depth variable at pleasure. The disk is placed concentrically within it; so that there are two cheese-shaped masses of water, one above, one below the disk, which are dragged into rotation on the side next to it, and retarded next the sides of the pan. The couple required to rotate the disks is equal to that formed by the disk or fluid when the motion is uniform. Hence the tendency of the chamber to rotate is measured by suspending it from a trifilar suspension. A weight suspended by a cord measures the force required to keep the index at zero. It appears that a rough cast iron disk has a frictional resistance almost exactly as the square of velocity; whereas a turned brass disk gives a value of x decidedly less than 2. The resistance is a little greater when the mass of water is larger. He proposes to try the effect of temperature on fluid friction in viscous as well as in mobile fluids.

Specific Magnetism of Iron—forms the subject of an essay by Dr. Auerbach of Breslau. He shows that this is not without influence on the galvanic behaviour of the metal. If a current be conducted through an iron wire, phenomena appear which do not occur with other metals. The following are some of the known facts:—

(1.) The actual galvanic conductivity has been very variously stated, between 12·35, and 15·9 per cent.

(2.) Resistance increases with rise of temperature.

(3.) The heat generated by the current, by Joule's law, is 448·0 as against 478·9 for copper.

(4.) On closing the circuit, an extra current takes place in the opposite direction; on opening, in the same direction.

(5.) Longitudinal magnetization of iron influences its resistance.

In examining the last (5) phenomenon, the great difficulty was to exclude the influence of temperature. An adiathermanous magnetizing apparatus was made by winding the copper on a wide glass tube, into which a caoutchouc tube was introduced, with a smaller glass tube within it; the wire itself being wrapped in paper.

Special arrangements were made also to reduce the intensity of (4) the extra current.

These due precautions having been observed, a large transient diminution of resistance, and a smaller permanent diminution, were observed, the former amounting to 2 per cent.

A New Form of Spectrometer—is described by Dr. J. W. Draper, differing from the ordinary spectroscope, in the fact that whereas that deals with wave-

lengths and frequency of vibrations, this measures amplitudes on the intensity and brilliancy of light. It depends on the optical principle that light becomes invisible when in the presence of light sixty-four times more brilliant.

His mode of operating is as follows:—

Remove from the common three-tubed spectroscope its scale tube, and place against the aperture into which it was screwed a piece of glass ground on both sides. In front of this arrange an ordinary gaslight attached to a flexible tube, so that its distance from the ground glass may be varied at pleasure. On looking through the telescope, the field of view is seen uniformly illuminated, the brilliancy depending on the distance of the gaslight, according to the ordinary photometric law. This is called the extinguishing light. If it be put out for a moment, and the luminous flame of the Bunsen burner so arranged that its spectrum is seen, on relighting it a spectrum is seen in the midst of a field of light, the brilliancy of which can be varied at pleasure. As the intensity of the latter is increased, the violet first disappears, then the other more refrangible colours in their descending order, till at length the red alone remains. The yellow never stands out conspicuously, as might have been expected. This is scarcely consistent with the opinion that the yellow is the brightest of the rays. Dr. Draper, therefore, thinks that the luminous intensity of the coloured spaces has a relation to the compression or condensation that the prism is impressing upon them. To diminish the intensity of the extinguishing light, an exceedingly thin film of silver was deposited on the face of the prism which acts as reflector. This, though quite transparent to the transmitted rays, increased by metallic reflection the extinguishing rays.

The same estimate was made more simply with sunlight, by introducing a beam from a Heliostat, and throwing its spectrum on a screen. The window-shutters were then more or less opened to admit ordinary light. When the shutters were wide open, the spectrum was quite obliterated; on gradually closing them, the red region first came into view, the other colours following in order of refrangibility. Irrationality of dispersion in various kinds of glass did not seem perceptibly to influence the results, nor did differences in the eyes, the age, or the visual powers of different observers.

Dr. Draper saw at once in the dispersion-spectrum a means of testing his views as above stated. Using a grating, and the spectrum of the first order, as the force of the extinguishing illumination increased, all the coloured spaces yielded equally and simultaneously, re-appearing in a similar manner. The same happened with solar as with gaslight.

Light from Thermo-Electricity.—M. Clamond appears to have overcome the difficulty of producing a battery of this nature fit to produce the electric light. It is formed of iron as the electro-positive element, and of an alloy of antimony and zinc for the negative. They are arranged in a circular form, heated in the interior. The latest form consists of a number of pieces of cast iron, named the *collector*, so arranged that heated air can circulate between them. A large surface is thus exposed to the heat, which the iron collects, and communicates to the couples. The *Diffuser* is the outside of the apparatus, and is made of sheets of metal. The thermopile itself is placed between these two, and is so arranged that the junctions of the

metals are alternately at the temperature of the collector and of the diffuser. The pattern now in use for lighting a workshop in Paris is 2½ metres high, and 1 metre in diameter. Another model, made for the exhibition at the Albert Hall, is square and smaller, though of the same power. Each half of the cylindrical battery can be made to supply a powerful electric light, while the square one can produce four lights of half the brilliancy. The electromotive force is, according to prolonged experiments, 218 Volts, about equal to 120 Bunsen cells, while the resistance is only ·31 Ohms. The large battery consumes 9 or 10 kilogrammes of coke an hour; the smaller, about 6½ kilogrammes. The large external surface of the apparatus, radiating its heat to the air around, fits it for warming purposes as well as for lighting.

The Optical Structure of Ice has been investigated by Herr Klocke, who confirms the observation that the optic axis is at right angles to the surface whence the cooling proceeds. The ice flowers which first cover the sides of the vessel, however, have their principal axis parallel to these. The axis, according to M. Bertin, has a definite direction only after a fairly thick stratum of ice has been formed, the first layer being confused in its mode of crystallization; but Herr Klocke shows that the first needles shooting over the surface are formed parallel to the principal axis, and their ice plates are added to their sides, the optic axis of which is at right angles to the surface of the water.

The Temperature of Carbons giving the Electric Light has been examined by M. Rossetti, by means of a thermopile, the face of which is placed at a suitable distance to receive rays from a radiating surface of determinate size; the thermal effect being measured by a sensitive reflecting galvanometer. He comes to the conclusions that—(1.) The positive pole has higher temperature than the negative. (2.) The temperatures vary according to the intensity of the current. (3.) They are higher, the smaller the radiating surface, provided it comprises the extreme point. (4.) In the negative pole the minimum temperature was 1910° cent., with a large radiating surface of small brilliancy; the maximum 2532° cent., the radiating surface being half the preceding. (5.) For the positive pole the minimum temperature was 2312°, the carbon being large; the maximum 3200°, with a thin carbon and small radiating surface.

The Velocity of the Wind at Sea has been tested by Admiral Serres in the French Frigate *La Magicienne*, a Robinson anemometer being observed daily at a height of 8 metres, and twice daily at that of 36 metres, from the sea level. With very rare exceptions it was found much greater in the latter case than in the former, the average ratio being 12 to 10. Hence the modern practice of increasing the high sails at the expense of the lower is justified by observation.

A New Form of Leclanché Battery has been introduced by the inventor, in which the high resistance of the older pattern is diminished, and the employment of a porous pot is dispensed with. The carbon is surrounded with a mixture of 40 parts of pyrolasite, 155 parts of grain carbon, and 5 parts of resin, the latter acting as a cement. This composition is heated to 100° cent., and subjected to a pressure of 300 atmospheres. It forms a homogeneous cylinder, in the centre of which is the carbon electrode. The in-

ventor terms it the "conglomerate mixture" battery. The electromotive force is also higher than in the older form. He has also recently added depolarizing plates, which can be renewed from time to time. They are simply attached by indiarubber rings to the carbon.

It appears from careful experiments that the electromotive force of this arrangement is 1·46 of a Daniell element, and the resistance when new ·718 S.U. The electromotive force, however, diminishes rapidly when the external resistance is low, recovering quickly when the battery is at rest.

Electro-Optic Observations on Various Liquids form the subject of a paper by Dr. John Kerr, of Glasgow, following up his important observations in 1875 on a new relation between electricity and light. He then showed the possibility of inducing double refraction in glass, carbon disulphide, and several other dielectrics, by the application of electric force. He now furnishes notes of a later and more extended series of experiments on the same subject. The methods are substantially the same as before; but the means of observation have been greatly improved by assistance from the Government Fund. He uses a new plate cell, made of a block of selected plate glass, three-quarters of an inch thick and 8 inches long. Two fine holes are drilled right through it; one parallel, the other at right angles to its length, crossing in the centre, equidistant from the two faces of the plate. Two other holes are subsequently made through the plate; one a tunnel, 1 inch high and $\frac{5}{8}$ inch wide; the second, a slightly tapering hole, into which is fitted a glass stopcock, so as to open and close the vertical boring. The electric terminals within the tunnel are two balls of brass, a quarter of an inch in diameter. To these two brass rods pass from the ends of the block, being made water-tight at the outer ends by india-rubber washers. The brass balls are strongly electro-plated with silver, and turned in the lathe so as to present flattened spheroidal surfaces to each other, distant by one eighth of an inch from one another. The cell is closed at either end by panes of plate glass, $\frac{1}{16}$ inch thick and 2 inches square, with interposed sheets of india-rubber. The whole is supported by glass pillars, terminating in a solid wooden stand. All is then covered by a thick coat of shellac varnish.

The cell thus constructed is filled with the fluid to be examined by means of a small funnel drawn to a fine end.

It is often necessary to introduce definite and very faint birefringent actions between polarizer and analyzer. For this purpose, slips are cut out of plate glass, $\frac{1}{16}$ inch thick, $\frac{7}{8}$ inch wide, and 7 inches long. When such a strip is forcibly extended by means of a weight, it acts on the transmitted light as does a positive uniaxial crystal, with its axis along the line of tension; when compressed, as a negative of similar power and position. These are termed optical compensators, some of which are fixed and constantly stretched by weights below sixteen pounds; others are held in the hand, with their long axes inclined 45° to the plane of polarization.

The various pieces are arranged as follows:—The ray is horizontal, furnished by a flat paraffin flame placed edgeways, passing first through a polarizing Nicol's prism; then through the cell above described, the two terminals being connected, one with the prime conductor of an electrical machine, the other to earth. Then follow two compensating plates of glass, mounted vertically, so as to admit of the attachment of stretching weights

to either or to both. A third neutralizing plate is sometimes required in delicate observations. Lastly is an analyzing Nicol's prism.

The polarizer is first placed at 45° to the axis of the electric field, and the analyzer turned to complete extinction of the ray. The cell, with conducting wires, is now interposed, and the light restored by the use of a hand-compensator, forming a fine streak passing midway between the balls in the cell. The cell is then charged with clean liquid, and the electrical machine is set at work. If carbon disulphide, by far the best dielectric yet discovered, be employed, a slight movement of the machine restores the extinguished light in the polariscope. As potential rises, the light becomes quite brilliant; but on taking a spark from the prime-conductor, it vanishes instantly. There is no rotation of the plane of polarization, since slight contrary rotations of the analyzer affect the ray equally and similarly. Carbon disulphide appears to insulate completely, sparks drawn with the cell in circuit being of the same length as when it is removed. The action of dielectrified carbon bisulphide is therefore the same as that of glass extended in a direction parallel to the lines of force, and is a uniaxial birefringent action. Of the two component vibrations polarized in planes parallel and perpendicular to the lines of force, the latter is retarded. Weights are now attached to the compensating slips, causing strong permanent restoration from extinction of the light in the polariscope. If the machine be then worked, a broad horizontal band of darkness crosses the flame in the axis of the field, becoming by degrees perfectly black. With increased potential the flame reappears as a speck in the centre of the band, until the band is broken up into two on opposite sides of the axis, concave to one another. With rising potential, they move symmetrically outwards from the axis, dividing the flame into three large segments of equal brightness. When the electric action is near spark-discharge through the liquid, the bands cross the flame just outside the cylinder enveloping the two balls. This experiment represents the crossing of positive uniaxial plates. With a tension of 12 to 16 lbs., the bands are distinct, narrow, sharply defined, and very black.

Benzol, toluol, xylol, cumol, cymol, terebene, and amylene, were tried in the same manner, yielding similar results. Carbon dichloride stands somewhat above benzol. Nitrobenzol, tested in the usual way, acts as a good conductor, and gives no optical effect. If, however, the earth wire be disconnected, and a spark taken from it to the band at the instant of discharge, there is a strong restoration of light from extinction. The same effect occurs less distinctly with amylene.

Stannic chloride gave remarkable but not easily defined results. Young's paraffin oil gave fine effects, similar to carbon disulphide.

The fixed oils of olives, sweet almonds, poppy seed, rape seed, colza, mustard, linseed, nut oil, lard oil, and neatsfoot oil, acted oppositely to carbon disulphide. Animal oil, such as sperm, acted similarly to that substance, and in an opposite manner to every other fixed oil.

On the Capillary Phenomena of Jets is the title of a communication from Lord Rayleigh to the Royal Society. It is in a manner supplementary to a previous paper "On the Influence of Electricity on Colliding Water Drops," abstracted in our Summary of July. Water issuing from a circular orifice under pressure, though forming a contracted vein, remains circular. If the

orifice be not circular, the section of the jet undergoes remarkable transformations, the peculiarities of the orifice being inverted and exaggerated in the jet. With an elliptical orifice of which the major axis is horizontal, the jet becomes circular at 30 lines, the vertical axis then increasing till the vein spreads into a flat vertical sheet which preserves its continuity to 6 feet from the orifice. An orifice shaped as an equilateral triangle furnishes a jet composed of three flat sheets disposed symmetrically round the axis, their planes being perpendicular to the sides of the orifice. A vein issuing from a regular polygon of any number of sides resolves itself into an equal number of thin sheets, with planes perpendicular to the sides of the polygon. This extension of the sheets has, however, a limit, and sections taken at greater distances show gradual shortening, ending in a return to the form of the first contraction. Beyond this point sheets are again thrown out, again to return to the original figure. The explanation of the phenomenon seems to depend on capillary force. The fluid behaves as if enclosed in an envelope of constant tension, the recurrent forms of the jet being due to vibrations of the fluid column about the circular figure of equilibrium, superposed upon the general progressive motion. The distance between consecutive corresponding points of the recurrent figure, or as it may be called the *wave-length* of the figure, is directly proportional to the velocity of the jet, *i.e.* to the *square root* of the head of water. But little variation in the magnitudes of successive wave-lengths is to be noticed, even in the case of jets falling vertically with small initial velocity. In the experiments described, the jets issued horizontally from orifices in thin plates adapted to a large cistern.

Tables of seven sets of experiments follow, giving the observed wave-length and square root of pressure for different heads of water. At the higher pressures the observed wave-lengths have a marked tendency to increase more rapidly than the velocity of the jet. The orifices were rectangular, elliptical, triangular, and square. It was found that the value of λ depends on the nature of the fluid; methylated alcohol, for instance, gave a wave-length twice that of water. If a jet of mercury discharging into dilute sulphuric acid be polarized by an electric current, the change in the capillary constant, discovered by Lippmann, shows itself by alterations in the length of the wave. A mathematical investigation of the above facts follows. The flow of a vein from circular orifices is next adverted to, and its resolution from a cylinder into drops. This phenomenon is much influenced by vibration of the orifice under the impact of the jet, and when the disintegration of the jet establishes itself with complete regularity, it is attended by a musical note. The pitch of this, due to a jet of given diameter, issuing under a given head, enables the wave-length of the nascent divisions to be at once deduced. The most certain method of obtaining complete regularity of resolution is to bring the reservoir under the influence of an external vibrator, the pitch of which is approximately the same as that proper to the jet. Savart found that the note might be a fifth above, and more than an octave below that proper to the jet. An electrically maintained tuning-fork is perhaps the best apparatus for the purpose. In consequence of the rapid motion, some optical device is necessary to render apparent the phenomena attending the disintegration of the jet. The shadow of the jet thrown on a ground glass screen from the electric spark illumina-

tion is suggested; or the jet itself may be observed if illuminated by the same spark diffused by passing through ground glass. The electrically maintained fork may be made to perform the double office of controlling the resolution of the jet, and of interrupting the primary current of the coil. The jet then illuminated in only one phase appears perfectly steady, and may be examined at leisure. In an appendix to this powerful but graceful monograph, the mathematical investigation of the motion of frictionless fluid under the action of capillary force, in the form of an infinite circular cylinder, and the vibrations of a liquid mass about a spherical figure, is worked out at some length.

ZOOLOGY.

Morphology of the Nervous System in Dipterous Insects.—Mr. J. Künckel has lately communicated to the Academy of Sciences (*Comptes rendus*, 1 *September*, 1879) a summary of the results of his researches upon the nervous system in the Diptera. He finds that in the arrangement of the ganglia forming the central chain, there may be a close centralization or union of the whole into an almost continuous mass, or an extreme separation of the nervous centres, with the most various intermediate groupings; but, at the same time, each family has its nervous system constructed upon a peculiar and invariable plan. One of his most curious results, is the discovery that in certain groups, namely, the Stratiomyidæ, Tabanidæ, Syrphidæ, Conopidæ, and certain Muscidæ Acalypteræ, the ganglia which were originally united in the larva become separated during the passage of the insect into the pupa; so that instead of being shortened, as in many insects, by the approximation of the ganglia, and the fusion of some of them, in these flies the ganglionic chain is actually lengthened in the imago, and some of the ganglia are passed into the abdomen.

In accordance with the evolution of the nervous system, M. Künckel suggests that the Diptera may be divided into three groups:—1. Those which follow the ordinary law, and in which some of the ganglia become fused together during the passage to the pupa stage (the *Nemocera* of the older Entomologists):—2. Those in which the ganglia separate at the same epoch (the families above-mentioned):—and 3. Those in which the thoracic and abdominal ganglia remain confounded, as in the larvæ (Muscidæ Calypteræ, Œstridæ, Hippoboscidæ, Nycteribiidæ). In all Diptera the ganglia are distinct and clearly separated in the embryo. In the larvæ of the first group they remain distinct; in those of the two other divisions, they tend constantly to approach each other, their coalescence increasing with the growth of the larvæ. In the pupæ of the second group there is a phenomenon of reversion, the nervous centres again separating; whilst in the pupæ of the third group they remain associated in a single mass.

M. Künckel passes in review the families of Diptera, which, as he says, differ in the value of the external characters on which they are based, and indicates the following as approximately equivalent groups:—the Hippoboscidæ, Nycteribiidæ, Œstridæ, and Muscidæ Calypteræ, which have the thoracic and abdominal centres united into a single mass, may form a special

group; the Conopidæ, and the greater part of the Muscidæ Acalypteræ having one thoracic and one abdominal centre, may form a second; the Syrphidæ, with one thoracic and two abdominal centres constitute a third very natural group; the Tabanidæ and Stratiomyidæ, with one thoracic and five abdominal masses, a fourth; the Therevidæ, which have two thoracic and five abdominal centres, and the Scenopinidæ, with three thoracic and five abdominal masses, form parts of special groups; whilst a seventh section, having two or three thoracic centres, more or less confounded, and always six abdominal centres, includes the Xylophagidæ, Empidæ, Asilidæ, Bonbyliidæ, Bibionidæ, Culicidæ, Tipulidæ, &c. This proposed grouping will hardly be accepted by entomologists, although in some particulars it is very suggestive.

The Cephalic Ganglia of Insects.—M. N. Wagner describes the structure and functions of the ring of ganglia surrounding the œsophagus in insects (*Comptes rendus*, August 11, 1879). According to him the subœsophageal ganglion has nothing to do with the general co-ordination of the movements of the insect; it chiefly governs the organs of the mouth, and differs but little in its histological structure from the other knots of the ganglionic chain. The supra-œsophageal ganglia he regards as truly cerebral, and as the seat of nearly all the functions of the cerebral hemispheres of the vertebrata. Hence their structure is more complex, although they are constructed upon the same general plan as the other ganglia. In the middle they present bundles of nerve-fibres, whilst the nerve-cells chiefly occupy the periphery. Towards the centre of the ganglion there are three small groups of cells one above the other and communicating by numerous fibres. The foremost group has the closest relations with the convolutions (or horse-shoe bodies), which are particularly well-developed in the social Hymmoptera, the most intelligent of all insects, and the author states that the development of these parts is coincident with the intellectual development. Thus it is most remarkable in the worker ants and the worker bees, and less striking in the female ant and queen bee. These parts are rudimentary in the males. From the sides of the ganglia issue the lobes which go to the compound eyes. These are oval, and formed in the middle of short cylinders arranged in rows. These cylinders give origin to fibres which penetrate to the base of the brain. In the external part of the optic lobes these fibres intercross and present the form of two flattened cones with their apices turned towards each other. In this way the fibres of the left side appear on the right side, and the inferior fibres become superior, and each fibre by thus changing its direction enters into the constitution of the optic nerve which runs to each of the eyes forming together the compound eyes. This organization probably causes a perfect coincidence of all the optical impressions received by each eye.

Nerves of the Proboscis of Diptera.—M. Jules Künckel has examined into the terminations of the nerves in the proboscis of the Diptera (*Assoc. Franç. Avancem. des Sci.*, 1878, p. 771). He remarks that the proboscis terminates in two valves, which, in repose, are laid against each other, but during suction are applied to the surface attacked so as to constitute a regular sucking cup. These valves represent the labial palpi. Their internal structure presents a peculiarity well known to microscopists;

they contain a large tube, from which issue numerous branches in a digitate form, and all these parts present an appearance like that of tracheæ. The name of *false-tracheæ* which has been given to them is perfectly justified, as they have no communication with the true tracheary apparatus, their principal function being to support the integuments of the palpi, whilst a true trachea ramifies in these organs. Parallel to the large trunk of the false-tracheæ the labial nerve may be traced, of comparatively large size. It speedily divides into two parts, and emits a multitude of ramifications to the periphery and inner surface of the valves. Those nervous filaments which run to the periphery go to the numerous and greatly developed hairs with which the margin of the valve is furnished; those which go to the inner surface on the contrary terminate at rudimentary hairs, reduced to a minute chitinous cylinder.

On examining the nervous terminations which run to the marginal hairs, it will be found that a filament separates from the ganglionic inflation, and goes to the hair, as has been already described and figured by M. Jobert, but that it terminates in the interior of the hair at the point where the latter is joined to the integument by a membranous part. On the other hand, in the case of the terminations which go to the rudimentary hairs, the filament will be seen to traverse the little cylinder and project outside in the form of any fine and delicate rounded point. There are thus in the proboscides of the Diptera (Muscidæ and Syrphidæ) two kinds of nervous terminations—one set connected with well-developed hairs, which are no doubt tactile in function; the other with rudimentary hairs of peculiar form, which are probably gustative.

The Vertebrate Skeleton.—M. Sabatier has propounded certain views as to the nature of the Vertebrate Skeleton which are slightly at variance with generally-received opinions, although we fancy that something analogous has already been suggested more than once. M. Sabatier denies the existence of the vertebral type, and regards the vertebra as nothing but the solidification of an intermuscular axis of connective tissue, the appendages of which are contingent and depend on the development and arrangement of the muscular system. Leaving out of consideration the cranium, the vertebral composition of which he regards as untenable in face of embryological data, M. Sabatier remarks with regard to the rest of the vertebral column:—

1. That the points of ossification are extremely variable as to number and position from one moment to another.

2. That the typical parts of the vertebra are often deficient, as, for example, the centrum, which is sometimes only an appendage of the neurapophyses.

3. That the parts of the vertebra are sometimes autogenous, sometimes heterogenous.

4. That the caudal ribs or hæmal arches of the tail in fishes completely change their signification, according as we have to do with osseous fishes, in which they are formed by the paraphyses, or with cartilaginous fishes, in which they represent true ribs.

5. That the lateral apophyses of the body of the vertebra are multiplied where the muscular system is complicated. Thus the four lateral apophyses of the lumbar vertebræ of the dog and of the large carnivora originate from

the expansion of a single tubercle of the dorsal vertebræ, because the sacro-lumbar muscles acquire great complexity and multiply their tendons at the level of the loins.

Hence M. Sabatier concludes that the vertebral type composed of necessary elements does not really exist, and that the apophysary elements of the vertebra are produced by the constitution of the muscular system.—(*Assoc. Franç. Avancem. Sci.*, 1878, p. 773.)

Hedgehog and Viper.—The common Hedgehog is generally described as a mortal enemy to snakes of all kinds, and it has been supposed that he enjoys an immunity from the effects of the bites of the venomous species. M. Samie with a circumstantiality which reminds one of the reports of prize-fights in "Bell's Life" during the palmy days of the ring, relates all the particulars of a combat which he excited between a Hedgehog and a Viper (*Vipera aspis*). The Hedgehog attacked the snake as soon as he was aware of its presence, seizing it in the first place at the hinder part of the body, and continuing his assaults until his formidable enemy was reduced to a helpless state, when he commenced eating it at the tail end; afterwards, proceeding to the head, he carefully detached and devoured the *lower jaw*. The Viper was still alive. The most interesting point brought out by this experiment of M. Samie's is the mode in which the Hedgehog defended himself against the dangerous weapons possessed by his adversary. When bitten, the Viper at first turned to strike its assailant, when the Hedgehog immediately drew forward over his head that mass of spines which forms the front part of his defences; and when the snake struck open-mouthed at its persecutor, its attack was foiled by this formidable *cheval-de-frise*. Several times the same manœuvre was repeated, until the snake's mouth was so severely lacerated that it no longer attempted to use its fangs, but sought safety in vain in flight. The Hedgehog frequently rolled himself up for a time after having made an attack upon his victim. M. Samie's results are interesting, but it is clear that he has not the fear of antivivisectionists before his eyes.—(*Actes Soc. Linn. de Bordeaux*, 1878, p. 257.)

Habits of Sphenodon (*Hatteria*).—Dr. W. L. Buller has communicated to the New Zealand Institute some observations relating to the habits and especially the food of the curious Lizards forming the genus *Sphenodon* (or *Hatteria*), two of which (*S. punctatus* and *S. Güntheri*) are now known to inhabit New Zealand. In captivity his specimens ate nothing for a considerable time, but on the approach of summer they fed freely, evincing a preference for flies and *Cicadæ*. Of the latter they sometimes devoured fifty in a day. They also fed freely on earthworms. After various vicissitudes including a period of violent cannibalism, it was accidentally found that they devoured small sea fishes three or four inches long with great avidity, a circumstance which, considering their general unwillingness to feed except on what may be regarded as their natural food, would lead one to suppose that small fish ordinarily form part of the diet of the Sphenodons. This would account for their fondness for water, in which they pass much of their time, and Dr. Buller found that they took to sea-water quite as readily as to fresh. He thinks that in their wild state they are probably amphibious.—(*Trans. New Zealand Inst.*, vol. xi. p. 349.)

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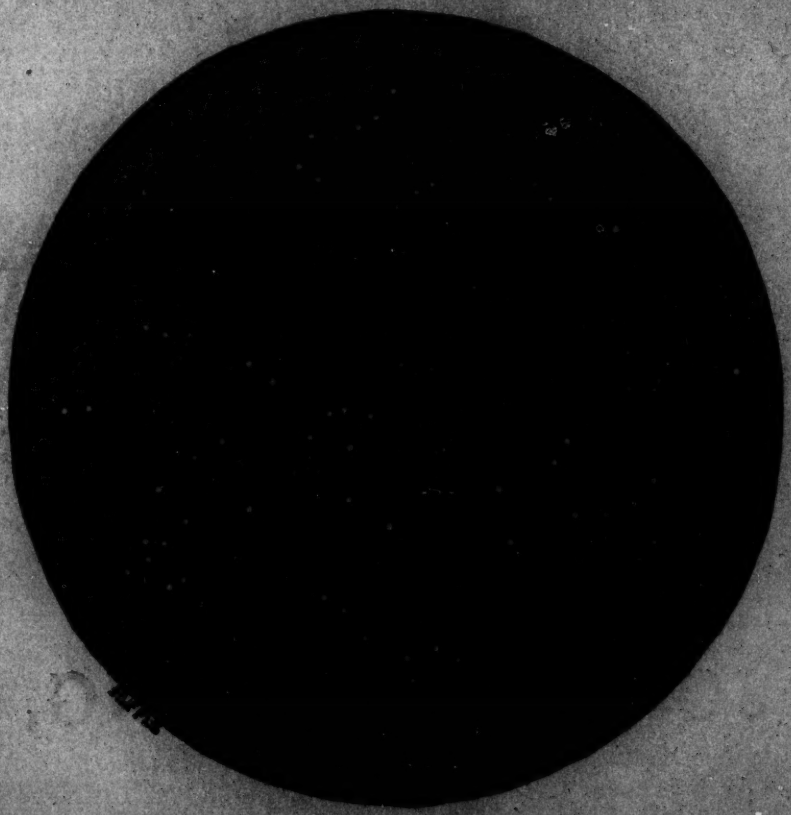

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